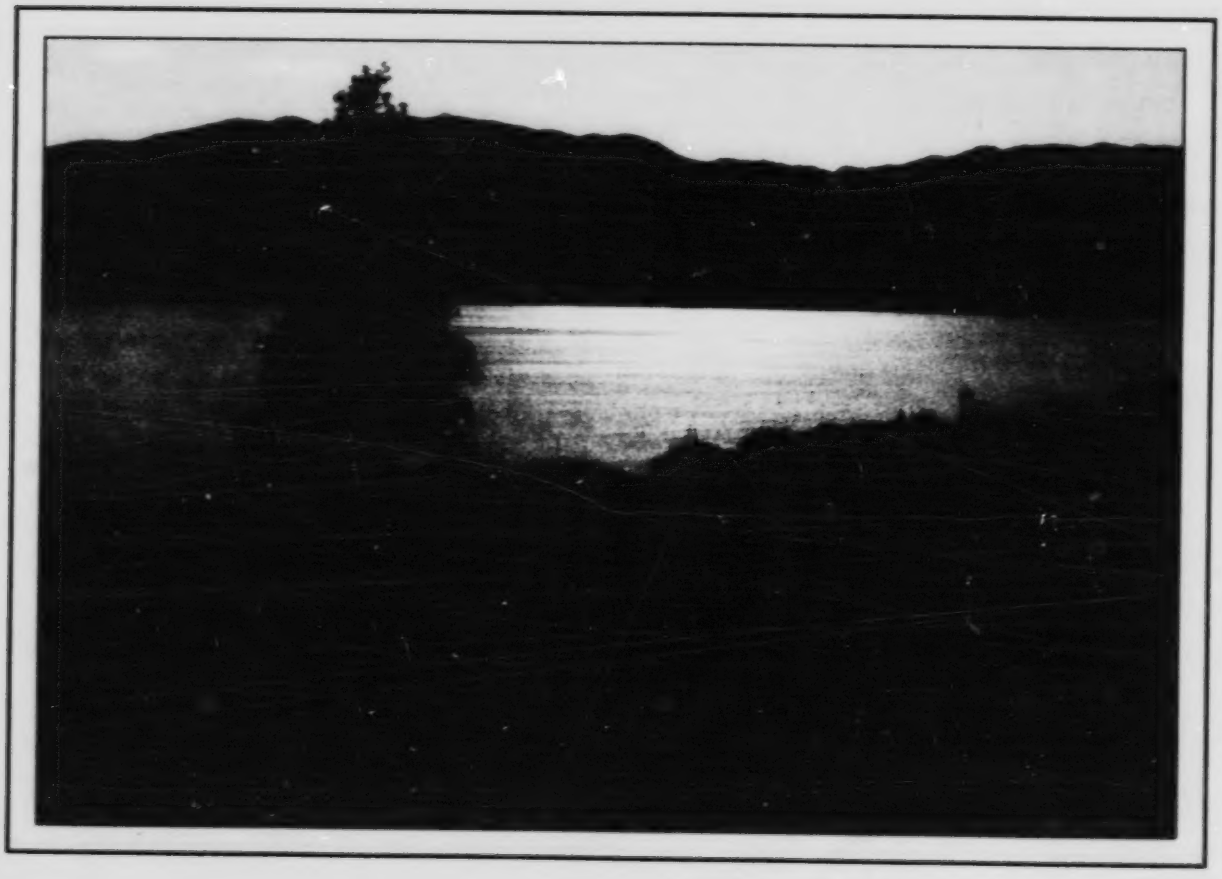
Pesticides

Research and Monitoring



Annual Report
1988 - 1989

Environment Canada
Environnement Canada

Canada

This publication is printed on paper containing recovered waste.

Pesticides Research and Monitoring Annual Report 1988-1989

91-04625/

Environment Canada

©Minister of Supply and Services Canada 1990
Catalogue No. En 40-11-13-1989E
ISBN 0-662-18461-0
BEAUREGARD PRINTERS LIMITED

Table of Contents

EXECUTIVE SUMMARY viii

PESTICIDES PROGRAM IN THE ATLANTIC REGION

1. Examination of the Influence of Helicopter Operating Parameters on Herbicide Drift in Conifer Release Programs 1
2. Off-target Deposit of Agricultural Insecticide Spray Applied by Aircraft and the Associated Impact on Aquatic Fauna 3
3. Incidence and Magnitude of Forest Pond Contamination by Fenitrothion 4
4. A Comparison of the Aquatic Toxicity of Fenitrothion Flowable and Fenitrothion Emulsion Formulations 5
5. Effects of Aerial Spraying of Fenitrothion on Breeding White-throated Sparrows 6
6. The Effects of Fenitrothion Spraying on Forest Songbirds as Determined by Measurement of Cholinesterase Depression 7
7. Avian Response to Orchard Pesticiding in the Annapolis Valley 9
8. Patterns and Trends of Organochlorine Contaminants in Eastern Canadian Seabirds 10
9. New Brunswick Subsurface Drainage Project: A Study of Effects of Intensive Agricultural Production on Water Quality 11
10. Groundwater Program, Canada/Prince Edward Island Water Management Agreement 12
11. Pesticide Migration and Fate in Groundwater 13
12. Federal-Provincial Drinking Water Sources Toxic Chemical Survey 14

13. An Application of SPANS Technology to Toxic Contaminant Monitoring in the Atlantic Region 15

14. Organic Contaminants in Precipitation 16

15. Dispersion of Dichlorvos from a Simulated Salmon Ectoparasite Control Project 17

16. Transport and Effects of Aerially Applied Chlorothalonil in a Small Pond 18

PESTICIDES PROGRAM IN THE QUEBEC REGION

1. Leaching of Metolachlor, Atrazine, and Atrazine Metabolites in Soil and Groundwater 21

2. Changes in Intracellular Free Amino Acids (FAA) in Caged Mussel, *Elliptio complanata*, in Agricultural Watersheds 23

3. Development of a Site-spec[illegible]Water Quality Objective for Atrazine in the Yamaska River 24

4. A Two-component Investigation on the Effects of Pesticides on the Biota (phytobiology) of a River in a Watershed Subject to Intense Agricultural Activity 26

5. Evaluation of the Medium-term Effects of the Use of Phenoxys and Glyphosate on Bird Populations in Black Spruce Plantations 28

6. Effects of the Application of Azinphos-methyl, Malathion, and Carbofuran on Nesting Birds in Apple Orchards and Strawberry Fields in Quebec .. 29

7. Effects of the Treatment of Ornamental Trees with Diazinon and Acephate on the American Robin in Urban Areas 30

PESTICIDES PROGRAM IN THE ONTARIO REGION

1. Federal Interdepartmental Quality Assurance on Pesticide Analysis 33

2. Canadian Water Quality Guidelines for Atrazine, Carbofuran, and Glyphosate 34

3. Screening Technique for the Detection of Atrazine in Surface and Groundwater 35

4. Use of Acetylcholinesterase to Detect the Effects of Sublethal Concentrations of Organophosphate Insecticides on Aquatic Invertebrates 38

5. Chemical and Photochemical Isomerization of Deltamethrin 39

6. 1,2-dichloropropane and 1,3-dichloropropene Methods Development 40

7. Pesticides in Southern Ontario Rainwater 42

8. Atrazine and Metolachlor in Agricultural Runoff .. 43

9. The Biological Impact of Agricultural Runoff from Conventional Versus Conservation Tillage: Effects on Primary and Secondary Productivity ... 44

10. Nematocides in Surface and Groundwater of Big Creek Watershed 46

11. Bioaccumulation and Biodegradation of Tributyltin 47

12. Biodegradation of Contaminant in Fluvial Systems 48

13. Environmental Dynamics of Benzothiazole-based Pesticide 49

14. Annual Monitoring of Contaminant Levels and Bioeffects in Fish-eating Birds on the Great Lakes I. Contaminant Levels in Herring Gull Eggs 51

15. Annual Monitoring of Contaminant Levels and Bioeffects in Fish-eating Birds on the Great Lakes: II. Congenital Anomalies in Embryonic and Post-hatch Double-crested Cormorants (DCCs) 52

16. Annual Monitoring of Contaminant Levels and Bioeffects in Fish-eating Birds on the Great Lakes: III. Breeding Biology of Herring Gulls and Forster's Terns in the Detroit/ St. Clair River Corridor 53

17. Wildlife and Agricultural Pesticides in Southern Ontario: Breeding Biology Parameters of Swallows, Bluebirds, and Kestrels Nesting Near Apple Orchards Along the Niagara Escarpment 54

PESTICIDES PROGRAM IN THE WESTERN AND NORTHERN REGION

1. Elie Aquifer Recharge Project 57

2. Monitoring Deposit of Deltamethrin in Prairie Wetlands By Aerial Applicators 59

3. Pesticide Investigations in Groundwater Beneath an Irrigated Field Near Outlook, Saskatchewan 60

4. Re-evaluation of In-use Pesticides 62

5. Effects of Bran-bait Pesticide Formulations on Non-target Organisms 65

6. Fate and Effect of Diclofop-methyl in an Aquatic Organism 66

7. Chronic Toxicity of Lindane, Triallate, and Trifluralin to Fathead Minnows and *Ceriodaphnia dubia* 67

8. Toxicity of Carbofuran Spray to Mallard Ducklings 69

9. Potential Secondary Poisoning Hazard of Rodenticides for Birds of Prey in Alberta 70

10. Feasibility of Using Bluebird Trails to Monitor the Effects of Insecticides on Songbirds 71

11. Extractability of Four Herbicides From Passive Organic Vapour Monitors (OVMs) 72

PESTICIDES PROGRAM IN THE PACIFIC AND YUKON REGION

1. Inventory of Pesticide Use in the Yukon - 1986 ... 77

2. Pesticide Distribution and Use Patterns in the Lower Fraser Valley 78

3. Abbotsford Outwash Aquifer Pesticide Study 79

4. Survey of Pesticide Contamination of Groundwater in High Risk Aquifers, Lower Fraser Valley 80

5. Preliminary Evaluation of Selected Pesticides in the Nicomekl Watershed and Proposed Approaches for Assessing Toxicity to Aquatic Biota 81

6. Distribution and Persistance of Diazinon in a Cranberry Bog 82

7. The Effects of Different Dilution Water Types on the Acute Toxicity of Glyphosate and its Formulated Products to Juvenile Pacific Salmonids and Rainbow Trout 84

PESTICIDES PROGRAM AT THE NATIONAL WILDLIFE RESEARCH CENTRE (NWRC) HULL, QUEBEC

1. Development of Guidelines for Testing Pesticide Toxicity to Nontarget Plants 87

2. Development of Data Bases on Bird Use of Agricultural Habitats 88

3. Agricultural Bird Census (ABC) in Canada 89

4. Risk to Threatened and Endangered Species from Pesticide Use 90

5. The Secondary Hazard of "Rid-a-Bird" Perches to Falcons 91

6. Further Studies on the Impact of Agricultural Pest Control Practices on the Burrowing Owl, A Threatened Species 92

7. Soil Incorporation of Cereal Seed and Granular Insecticides Used During Canola Seeding Operations 93

8. Evaluation of the Usefulness of Avian Reproduction Studies as Currently Designed 94

APPENDIX
ENVIRONMENT CANADA'S INPUT TO DECISION DOCUMENTS 95

INDEX 101

Executive Summary

This is the third annual report of Environment Canada's pesticides program summarizing the results of projects in research and monitoring undertaken in 1988-1989 by the various sectors of the department. The projects are grouped into six sections based on the location where the work was actually conducted.

The following is a brief summary of the projects undertaken in each of the five regions of Canada and at the National Wildlife Research Centre (NWRC).

In the Atlantic region, projects were undertaken to examine the influence of helicopter speed and altitude on herbicide drift in conifer-release programs, and to measure off-target deposit of agricultural insecticide spray applied by aircraft and the associated effects on aquatic fauna.

The region was also involved in a number of projects on fenitrothion. Studies were conducted to determine the extent of pond contamination in forests sprayed with fenitrothion and the acute toxicity of different fenitrothion formulations to fish, clams, mussels, and *Daphnia*. Projects were also undertaken to assess the effects of aerial spraying of fenitrothion on white-throated sparrows and forest songbirds. The effects of pesticide spray on bird populations in orchards in the Annapolis valley and the patterns and trends of organochlorine contaminants in eastern Canadian seabirds were assessed.

The persistence of pesticides in subsurface drainage from potato fields and the contamination of groundwater by pesticides, including aldicarb, in Prince Edward Island were investigated.

Other studies in this region were concerned with chemical contaminants in wet precipitation, the dispersion of dichlorvos from salmon pens, and the movement of chlorothalonil off potato fields sprayed with the fungicide.

The Quebec region conducted studies on leaching of metolachlor, atrazine, and atrazine metabolites in soil and groundwater, and on the amino acid content of caged mussels exposed to toxicants in the Yamaska River. The toxicity of pesticides to aquatic phytoplankton and to bird populations in forests, orchards, and the urban environment were also investigated.

The Ontario region assessed several new techniques for monitoring pesticides in the environment. The suitability of commercially available immunoassay kits for pesticide analysis and the development of a method to measure exposure of aquatic insects to low concentrations of organophosphate insecticides were conducted. In addition, the region developed methods to analyze for deltamethrin isomers, and for 1,2-dichloropropane, and 1,3-dichloropropene.

Several pesticide monitoring projects were conducted in this region. The levels of herbicides in rainwater in southern Ontario and the amount of atrazine and metolachlor in agricultural runoff from land subjected to conservation and conventional tillage practices in southwestern Ontario were determined. Concentrations of 1,2-dichloropropane and 1,3-dichloropropene in the Big Creek watershed were investigated.

The toxicity of herbicide runoff on the growth and productivity of algae and aquatic invertebrates, and the bioaccumulation of tributyltin by caged mussels in contaminated harbours and sediments were measured. In addition, laboratory studies on the transformation, water solubility, and partition of a wood protection chemical TCMTB in water/sediment were conducted.

Levels of pesticides in eggs of herring gulls and the rate of occurrence of developmental abnormalities in double-breasted cormorants in the Great Lakes region were investigated. The region also monitored bird, mammals, earthworms, and insect populations exposed to spray events in apple orchards in southern Ontario.

The Western and Northern region was involved in a number of pesticide monitoring programs. The water quality of the La Salle River in Manitoba with respect to agricultural chemicals was assessed by examining the levels of insecticides and herbicides in water during late summer and early fall, and a project was conducted to determine the extent to which aerial application of deltamethrin resulted in contamination of slough waters. The groundwater under irrigated farmland near Outlook, Saskatchewan was also monitored for pesticide contamination. Reports summarizing the environmental fate and toxicity of MCPA, glyphosate, difenzoquat, triallate, pentachlorophenol and creosote have been compiled.

In addition, this region conducted a number of studies to determine the effects of pesticides on non-target organisms. The effects of bran-bait insecticide formulations on ground-dwelling beetles, leafcutter bees, rainbow trout, and *Daphnia,* and the fate of diclofop methyl and its effects on selected planktonic and benthic organisms in an aquatic micrososm were investigated. The toxicity of lindane, triallate, and trifluralin to fathead minnows and Ceriodaphnia, and the toxicity of carbofuran spray to mallard ducklings were also conducted. Levels of strychnine in poisoned ground squirrels and effects on nestling hawks fed the poisoned animals were reported. A project was also undertaken to evaluate the feasibility of using bluebird trails to monitor the effects of insecticides on songbirds.

In the Pacific and Yukon region, an inventory of pesticide use in the Yukon for the year 1986, as well as a survey to determine pesticide distribution and use patterns in the lower Fraser Valley were conducted. The groundwater from the Abbotsford aquifer was monitored for pesticide contamination and water from the Nicomekl River was assessed for agricultural runoff of dinoseb and endosulfan. In addition, the persistence of diazinon in water and sediment of cranberry bogs sprayed with the insecticide was investigated. The region also conducted studies to determine the toxicity of glyphosate, glyphosate formulations and a surfactant to juvenile salmon and rainbow trout in natural waters.

The National Wildlife Research Centre (NWRC) was involved in preparing guidelines for testing pesticide toxicity to non-target plants, in developing data bases on the use of agricultural habitats by birds, and in establishing an agricultural bird census (ABC). Studies were also conducted to identify those pesticides that might place threatened and endangered species at risk, and to determine the secondary toxicity of "rid-a-bird" perches and strychnine-poisoned gophers to avian predators and to burrowing owls, respectively. Other studies conducted by NWRC included a determination of the amount of unincorporated pesticide granules following canola seeding operations and an evaluation of the usefulness of avian reproduction studies currently submitted by industry.

Included in this report is a decision document summarizing the environmental fate and effects of clofentizine, a miticide.

An index is included at the end of this report to enable readers to easily identify studies related to a particular topic. Readers are encouraged to pursue the articles pertaining to their areas of interest and to contact the individual(s) listed at the end of each article for more information.

PESTICIDES PROGRAM IN THE ATLANTIC REGION

(Nova Scotia, New Brunswick, Prince Edward Island, Newfoundland)

1. EXAMINATION OF THE INFLUENCE OF HELICOPTER OPERATING PARAMETERS ON HERBICIDE DRIFT IN CONIFER RELEASE PROGRAMS - (D. Crabbe (NRC), D. Kristmanson (UNB), P. McCooeye (NRC), R. Mickle (AES), C. Riley (RPC), C. Wiesner (RPC))

Introduction. The aerial application of herbicides to release conifer plantings from competing vegetation is a critical element of reforestation and silviculture. Due to the high application volumes currently being used, aircraft productivity is low (typically 1 to 2 minutes of boom-time per load) and application costs are high. Aerial herbicide applications have received substantially less research attention than corresponding insecticide application but interest in this field is rapidly growing. Forest managers see an urgent need to improve economy and efficacy while minimizing environmental impact. To date, some studies relating to forestry use have included atomizer characterization, bufferzone definition and drop size/efficacy.

Preliminary results of glyphosate helicopter drift trials carried out in 1987 suggest that under certain operating conditions, large (150 μm) drops can move significant distances and result in downwind deposits substantially higher than indicated by some earlier "worst-case" studies. That study suggested that specific helicopter operating parameters (flight speed and altitude) may, in large part, be responsible for such observed differences.

The influence of air speed and altitude on off-target drift and deposit from a Bell 206 helicopter using D10-45 hydraulic nozzles was examined. By means of a dual tracer technique, the swath deposit and off-target drift and deposit were also measured for a Turbo Thrush using 4-AU4000 flooded Micronair rotating atomizers spinning at 2500 rpm. The specific objectives were:

1) to determine the effect of two flight speeds on helicopter vortex behaviour and drift/deposit;

2) to determine effect of three flight altitudes on helicopter vortex behaviour and drift/deposit;

3) to determine swath deposit and off-target drift and deposit from fixed-wing/Micronair applications;

4) to establish correlations between drift-cloud flux and deposit on natural weed species.

Methodology. During September 1988, a total of thirteen spray trials were conducted in the vicinity of Red Rock, New Brunswick. Each trial involved a Bell 206B, provided by New Brunswick Department of Natural Resources and Energy (NBDNRE), and an Ayres Turbo Thrush, provided by J.D. Irving, spraying a glyphosate simulant labelled with a different dye and chemical tracer. The aircraft sprayed alternately in cross-wind conditions over a single flight line for a total of three runs per trial. Spray deposit was measured from 0 to 600 m downwind on flat plate collectors situated at the top of the weed canopy (ca 100 cm), on foliage simulators within the weed canopy and on native weed foliage. Spray drift was collected to heights of 200 m above ground level at 200 and 550 m downwind of the spray line using balloon-borne rotorods. The operating parameters which were examined as independent variables were spray height for the Thrush and the Bell (7.6 m, 15.2 m, 24.4 m) and also flight speed for the Bell (22.4 m/s, 35.8 m/s). Wind speeds for all 13 trials ranged from 1.4 to 6.1 m/s.

Spray deposits on flat plate collectors have shown that for the Bell 206B, neither wind speed, aircraft (A/C) height nor aircraft speed had any significant effect on integrated spray deposition to 600 m. Drift measurements at 200 m and 550 m confirmed the non-correlation with A/C height but showed a weak correlation of increased drift with increased wind speed. Drift beyond 550 m ranged from 1% to 22.5% of the emitted spray over the thirteen trials. Emitted spray accountability from the flat plat deposit and drift varied from 70 to 100%. In the case of the Ayres Turbo Thrush only speed gave a marginally significant

correlation with integrated spray deposit to 600 metres.

The location of the peak deposit and swath width were found to be essentially the same for both aircraft flying at the same height. The downwind displacement of the observed peak deposits increased with increasing wind speed and aircraft height. Helicopter speed had no significant effect on either location, size of the peak deposit or swath width. In the case of the Bell 206B, swath width increased with increased aircraft height and wind speed. For the Ayres Turbo Thrush, only wind speed had a significant effect on the swath width.

Results from the preliminary field trial suggest that the performance of a rotary and fixed wing aircraft is essentially the same under similar conditions. However, improved spray strategy incorporating higher winds, higher A/C heights and possibly smaller drops may lead to more uniform and efficacious deposit within the spray block with reduced off-target contamination.

For more information, contact:

R.E. Mickle
Atmospheric Environment Service
Environment Canada
4905 Dufferin St.
Downsview, Ontario
M3H 5T4

(416) 739-4851

2. OFF-TARGET DEPOSIT OF AGRICULTURAL INSECTICIDE SPRAY APPLIED BY AIRCRAFT AND THE ASSOCIATED IMPACT ON AQUATIC FAUNA - (W.R. Ernst, P. Jonah, K. Doe, G. Julien, and P. Hennigar)

Introduction. Aerial drift from pesticide spray applications can result in contamination of non-target environments, particularly aquatic systems. One method of attempting to prevent that unwanted deposit is to implement buffer zones around sensitive aquatic areas where pesticides may not be directly sprayed. The width of such buffer zones depends on the kinetics of off-target spray droplets and the toxicity of the pesticide to exposed fauna. This study measured the off-target deposit and the associated aquatic effects, on several species of aquatic fauna, of an agricultural pesticide spray applied by aircraft, to determine the size of buffer zones necessary to protect aquatic systems.

Methodology. Deposits of aerially applied endosulfan were collected on flat plate samplers and in containers of water placed at various distances downwind of the treated area. The contaminated water was subsequently used to conduct 24-h lethal bioassays in a nearby temporary laboratory, using threespine stickleback (*Gasterosteus aculeatus*), water boatmen (*Sigara alternata*), caddisfly larvae (*Limnephilus* spp.), bivalve molluscs (*Pisidium* spp.), bloodworms (*Chironomidae* spp.) and water fleas (*Daphnia magna*). Three different spray events were sampled, all of which occurred at times when meteorological conditions were within regulatory constraints.

Results and Discussion. Chemical analysis of deposit collectors and exposed water indicated that deposit decreased in an exponential manner with distance downwind and ranged from 82 mg/m^3 and 1.7 mg/L for plates and waters within the target site to 0.051 mg/m^3 and 0.004 mg/L for plates and waters at 200 m downwind. After 24-h exposure to spray-drift contaminated water, no mortalities which could be attributed to the pesticide were observed for bivalve molluscs, bloodworms, or water fleas, even within the treated area. Water boatmen, caddisfly larvae and threespine stickleback, on the other hand, suffered levels of mortality which varied directly with distance downwind from the treated area. The distances at which 50% mortality was measured in water boatmen and caddisfly larvae tests were 50 m and 10 m, respectively. Threespine stickleback were the most sensitive species tested and they had mortality rates of up to 90% at a distance of 200 m downwind. These results demonstrate the extreme hazard to aquatic organisms from drift deposit of aerially applied endosulfan and indicate the need for similar assessments of other popular pesticides.

For more information, contact:

W.R. Ernst
Environmental Protection
Conservation and Protection
Environment Canada
15th Floor, Queen Square
45 Alderney Drive
Dartmouth, N.S.
B2Y 2N6

(902) 426-6141

3. INCIDENCE AND MAGNITUDE OF FOREST POND CONTAMINATION BY FENITROTHION - (W. Ernst, G. Julien, and P. Hennigar)

Introduction. Fenitrothion has been the chemical of choice in spray programs against forest defoliators in the Atlantic Region for over twenty years. Contamination of watercourses by fenitrothion is an unavoidable aspect of such spraying. A recent review, conducted by Conservation and Protection, Atlantic Region, has indicated that although most watercourse contamination does not cause substantial effects, there are certain watercourses which are theoretically at high hazard. These are small, still water bodies, such as forest ponds. Studies have indicated that at simulated operational dosage rates, the effects on aquatic invertebrates in small bog ponds are of such magnitude as to alter energy flows and threaten ecological integrity. Those water bodies are among the most difficult to detect from the air and therefore protect with buffer zones. The exposure to fenitrothion that small ponds receive during operational spray programs had not been measured and therefore the risk could not be assessed.

Methodology. Ten ponds within operational forest spray blocks were selected for observation. Immediately before spraying, flat plate deposit samplers were evenly distributed over the surface of each pond. Within a short time after spraying (15 minutes) residues on deposit samplers were collected along with a similar number of surface water (top 1 cm) samples from the pond and its outflow. The fenitrothion content of conifer vegetation adjacent to the ponds was also determined before and after spraying.

Results and Discussion. Ground observations at the time of spraying indicated that none of the ponds were subject to set-backs and therefore received direct application. Problems in flight line alignment resulting in "skipped" lines or "double swathing" were noted in three of the ten applications. Fenitrothion content of sprayed vegetation indicated deposits that were very comparable to those observed previously after similar spray programs. Mean concentrations in surface water from individual ponds ranged from 0.02 to 1.5 mg/L. These values are much higher (up 100 times) than the mean maximum concentrations previously observed in lentic systems and within the range of concentrations known to be acutely toxic to endemic fish and invertebrate species. The need to protect such water bodies from direct application of fenitrothion was established.

For more information, contact:

W.R. Ernst
Environmental Protection
Conservation and Protection
Environment Canada
15th Floor, Queen Square
45 Alderney Drive
Dartmouth, N.S.
B2Y 2N6

(902) 426-6141

4. A COMPARISON OF THE AQUATIC TOXICITY OF FENITROTHION FLOWABLE AND FENITROTHION EMULSION FORMULATIONS - (W.R. Ernst and K. Doe)

Introduction. Fenitrothion has been the chemical of choice for the control of the spruce budworm (*Choristoneura fumiferana*) in Canada for the past two decades. The opeational spray programs have employed emulsion formulations containing liquid technical fenitrothion. A recent development is the production of a "flowable" formulation which consists of finely milled particles of the active ingredient in suspension. The presence of the pesticide in a particle form has the potential to alter its bioavailability.

Methodology. A series of acute tests (48- and 96-h LC_{50}s) was undertaken to compare the aquatic toxicity of conventional (liquid technical) fenitrothion emulsions with that of the "flowable" (particulate) formulation. The species tested were: rainbow trout (*Oncorhynchus mykill*); threespine stickleback (*Gasterosteus aculeatus*); freshwater clams (*Anodonta* spp.); blue mussels (*Mytilus edulis*) and the water flea (*Daphnia magna*). Uptake comparisons were made with those two formulations using blue mussels.

Results and Discussion. In acute toxicity tests, for most species, the toxicity of liquid technical formulation was not substantially different from that of the particulate formulation. The exception was that the particulate formulation was less toxic than the liquid technical formulation to the freshwater clam by a factor of 1/3 to 1/5. Bioconcentration factors to blue mussels for the flowable formulation (15 to 36) were approximately 1/8 to 1/2 the blue mussel bioconcentration factors previously reported for the liquid technical formulations. The results indicate that the flowable formulation does not represent an increased hazard to the aquatic organisms tested, compared with the conventional liquid technical formulations.

For more information, contact:

W.R. Ernst
Environmental Protection
Conservation and Protection
Environment Canada
15th Floor, Queen Square
45 Alderney Drive
Dartmouth, N.S.
B2Y 2N6

(902) 426-6141

5. EFFECTS OF AERIAL SPRAYING OF FENITROTHION ON BREEDING WHITE-THROATED SPARROWS - (D.G. Busby, L.M. White and P.A. Pearce, Canadian Wildlife Service)

Introduction. Aerial spraying of spruce-fir forest for control of spruce budworm in New Brunswick has been an annual event since 1952, the spray program varying with the intensity and extent of the infestation. Although a variety of chemical insecticides has been used, fenitrothion has been the one of choice in the last two decades. One of the environmental concerns regarding extensive aerial spraying of forests with fenitrothion is its potentially harmful effect on songbirds which occupy the forest canopy together with the target insect. Spraying occurs near the peak of insect abundance when many forest birds are breeding. There is considerable potential, therefore, for insecticide spraying to interfere with recruitment of young birds, both through direct mortality and sub-lethal effects on the birds' ability to reproduce successfully. There have been few studies in which reproductive success of birds in the wild has been directly assessed after spraying of cholinesterase-inhibiting insecticides, such as fenitrothion. The present investigation was undertaken to examine territory maintenance and reproductive success of White-throated Sparrows exposed to fenitrothion spraying. The White-throated Sparrow is an abundant, well-distributed forest bird nesting on the ground typically in forest openings such as cutovers. It is believed to be as exposed and vulnerable, as those songbirds inhabitating the forest canopy.

Methodology. Various reproductive variables and indices of reproductive success were measured in a population of White-throated Sparrows exposed in a forest cutover to fenitrothion spraying at 420 g/ha followed by a second spray eight days later at 210 g/ha. The first application was designed to simulate conditions resulting in greater-than-average exposure of birds, such as would be expected to occur as a result of over-swathing (a not infrequent event in operational forest spraying), of particular meteorological conditions, or in open-canopy forest. All territorial White-throated Sparrows in the study were marked so as to be individually recognized. A total of 20 nests, containing unhatched eggs before the first spray event, were monitored intensively in sprayed and unsprayed control areas. Birds were collected for brain cholinesterase determination from parts of the cutover adjacent to the experimental spray area.

Results and Discussion. The behavioural response of breeding birds to the insecticide included territory abandonment, inability to defend territory, disruption of normal incubation, and clutch desertion. The breeding adult population was reduced by one-third, primarily a consequence of mortality and territory abandonment after the first spray. Clutch size and hatching success were not significantly different between the sprayed and control study populations. Reproductive success in the sprayed area was only one-third of that in the control area. Potentially life-threatening levels of brain cholinesterase inhibition were found in one-quarter of the birds after the first spray and in six percent after the second one. The observed effect on territory maintenance and reproductive success was related to a mean brain cholinesterase inhibition of 42% and 30%, respectively, after the two sprays, a finding facilitating comparisons of avian responses to sprays with other studies in which cholinesterase inhibition was assessed.

The results of the investigation were critical to development of a position against the continued widescale use of fenitrothion in forest protection, and to a determination that a re-evaluation of the registered forestry use-pattern of fenitrothion should be undertaken.

For more information, contact:

D.G. Busby
Canadian Wildlife Service
P.O. Box 1590
Sackville, N.B.
E0A 3C0

(506) 536-3025

6. THE EFFECTS OF FENITROTHION SPRAYING ON FOREST SONGBIRDS AS DETERMINED BY MEASUREMENT OF CHOLINESTERASE DEPRESSION - (D.G. Busby, and P.A. Pearce (Canadian Wildlife Service) and D. Lemon (S. Fudge and Associates Limited)

Introduction. Fenitrothion has been the chief chemical insecticide used since the late 1960s to protect Canadian conifer forests against defoliating insects. Aerial spraying programs against the spruce budworm have long been annual events in New Brunswick and other eastern provinces, sometimes several million hectares being sprayed in any given year. The hemlock looper has been a particular problem in Newfoundland.

Management of forest insect pests is a biologically complex problem and the practice of control through chemical insecticide spraying has continued to be a publicly controversial and politically sensitive issue. An accelerating trend to greater reliance on more environmentally benign biological insecticides has been noted.

Advancing spray technology has sought to increase the efficacy of chemical insecticides while reducing the amount injected into the environment. The Canadian Wildlife Service has kept pace by undertaking monitoring and research studies on the effects of fenitrothion, in different spray packages, on forest songbirds. In the process, it has utilized and developed sensitive field and laboratory techniques to assess effects on birds, one being the measurement of the enzyme cholinesterase, an important indicator of exposure.

The accumulated evidence indicates that at currently prescribed operational spray rates, fenitrothion causes toxic effects in birds, which may include mortality, particularly where spray deposits in the target area are high.

Methodology. The study, with both field and laboratory components, was done in the context of operational spraying against the hemlock looper in Newfoundland and efficacy trials against the spruce budworm in New Brunswick. In Newfoundland, sprays were delivered by a four-engine DC-6 aircraft equipped with boom and nozzle spray hardware and electronic guidance instrumentation. Spraying was done in New Brunswick by single-engine TBM aircraft fitted with rotary atomizers, guidance being visual. Spray dosage rates were conventional - two applications at 210 g/ha - except that in the New Brunswick experiment a dosage rate of 140 g/ha was included.

The effects on birds were determined by measurement of brain cholinesterase depression in Tennessee, Magnolia, Bay-breasted and Blackpoll Warblers, and in White-throated Sparrows sampled in the sprayed forest and in unsprayed control areas. Cholinesterase depression of 50% in birds in the wild, where they are subject to many natural environmental stresses, is considered to be a life-threatening threshold.

Results and Discussion. In Newfoundland, 17% of all birds sampled exhibited brain cholinesterase depression of over 50%. However, effects were much more pronounced in two of the six operational spray blocks monitored there. In one of them, 34% of sampled birds suffered cholinesterase depression over 50% after a single spray. In the other, in which there was a split application of sprays, cholinesterase depression over 50% occurred in 35% and 19% of the birds sampled after the first and second spray, respectively. By contrast, in the remaining four blocks the spray effect was light, only 3% to 6% of sampled birds having cholinesterase depression greater than 50%.

In the New Brunswick trials, 17% to 18% of the sampled birds suffered cholinesterase depression greater than 50% in both the heavy (210 g/ha) and light dosage (140 g/ha) block, respectively. Both spray regimes caused an effect on birds greater than seen in an operational spray context in New Brunswick since 1978, when cholinesterase analysis became the standard for assessing spray effects on birds. In the present study, responses to the spray were greatest in the White-throated Sparrow, levels of cholinesterase depression being

comparable to those determined in an earlier investigation in which severe reproductive and behavioural effects were demonstrated in that species.

This investigation illustrated the great variability in the response of birds within a spray regime, insecticide formulation, delivery and emission factors all being held constant, supporting the findings of other studies of bird effects resulting from the spraying of fenitrothion and other forestry insecticides. That variability may be a function of forest structure, terrain, local meteorological conditions, and of the overswathing that occurs during operational spraying, or any combination of factors that results in spray deposits, and exposure of birds, being relatively high.

Although no further light was shed on the matter, earlier studies by the Canadian Wildlife Service suggested that aspects of forest spray technology are relevant to the risk to birds. It would be difficult to factor out the critical elements in a field situation where there are so many obscuring variables.

Reduction of the amount of insecticide active ingredient in the chemical spray formulation is desirable from an environmental standpoint, but the results of our study indicated that such a direction may not necessarily be accompanied by a lowered risk to birds.

This investigation reinforces our position that the margin of safety of fenitrothion for forest songbirds is narrow, and contributed to a decision to undertake a review of the effects of that insecticide on birds, with the object of determining whether a re-evaluation of the forestry use-pattern should be sought.

For more information, contact:

D.G. Busby
Canadian Wildlife Service
P.O. Box 1590
Sackville, N.B.
E0A 3C0

(506) 536-3025

7. AVIAN RESPONSE TO ORCHARD PESTICIDING IN THE ANNAPOLIS VALLEY -

(J.S. Boates, Biology Department, Acadia University)

Introduction. Modern apple orcharding is characterized by the use of chemical pesticides. Early reliance was on organochlorines, mercurials and other chemicals of low biodegradability. Recently, more ephemeral but highly toxic organophosphorus and carbamate compounds have been used. Fungicides and insecticides (and sometimes herbicides and rodenticides) are applied routinely, many of which were registered when the requirements for environmental fate and effects data were less stringent than today. Many sprays are applied during the critical breeding season of birds frequenting the orchards. Breeding bird surveys conducted in the Annapolis Valley in 1949 and 1984 indicate that the diversity of bird species has decreased significantly and population densities are low. Suggested causes include direct and indirect toxic effects of chemical sprays, disturbance during spray operations, and changes in the age and structure of the orchards over time. A PESTFUND supported, exploratory investigation was conducted to determine whether bird populations differed between sprayed and unsprayed orchards in the Annapolis Valley and whether pesticide spraying was a critical factor.

Methodology. Eight orchards, four sprayed and four unsprayed, were selected for study. Nesting platforms for American Robins, and nest boxes for American Kestrels and Tree Swallows were set out in an attempt to increase local populations of those species to facilitate the investigation. Bird counts and nest searches were conducted regularly in each orchard. Clutch size, hatching and fledging success, and nestling growth rates were determined for the nest-box population of Tree Swallows. The diversity and abundance of invertebrates serving as food for the birds was indexed for each orchard. In addition, detailed information was assembled on past and present use of chemical pesticides in the orchards selected for study.

Results and Discussion. The study protocol had to be adjusted considerably to address unforeseen difficulties in the field. It was possible to undertake detailed examination of only one species, the Tree Swallow, local populations being manipulated through the deployment of nest boxes. The main conclusions were as follows. There was a tendency for fewer Tree Swallow nest boxes to be occupied in the sprayed orchards. There were no differences in various parameters of reproductive success between birds in sprayed and control orchards. The diversity and abundance of aerial insects on which Tree Swallows feed did not differ significantly among the orchards studied. Information was gained on the diversity of bird species frequenting both sprayed and unsprayed orchards. Although breeding birds appeared to be more abundant in unsprayed orchards, bird counts and nest searches yielded inconclusive data. In all, 17 different pesticides were used in the study orchards, a maximum of nine in any one.

The conclusion stemming from this initial, rather broad examination of orchard pesticiding and the response of birds was that, although the information gained was limited, there was no major deleterious effect on birds. The approach was not designed to detect more subtle effects. A more focussed examination was planned for 1988 of the effects on the Tree Swallow of one particularly toxic pesticide (azinphos-methyl, a powerful cholinesterase inhibitor), with field and laboratory components seeking to measure mechanisms and intensity of exposure to sprays, and bird behavioural responses.

For more information, contact:

P.A. Pearce
Canadian Wildlife Service
P.O. Box 400
Fredericton, N.B.
E3B 4Z9

(506) 452-3086

8. PATTERNS AND TRENDS OF ORGANOCHLORINE CONTAMINANTS IN EASTERN CANADIAN SEABIRDS - (P.A. Pearce, J.E. Elliott, D.B. Peakall, and R.J. Norstrom, Canadian Wildlife Service)

Introduction. The sea is the ultimate sink for many toxic substances, through continental runoff, atmospheric transport, biological transfer, or deliberate dumping. Seabirds are members of high trophic levels of marine ecosystems, and recognized as valuable integrators over wide areas of marine pollution by lipophilic compounds. Seabird eggs can be collected at low cost and with minimal effect on populations. There have been few systematic, long-term studies of marine pollution as expressed by chemical contaminants in seabird eggs. The main objectives of the one summarized here are the provision of data on trends in chemical contamination of the marine environment and possible implications for seabird health.

Methodology. Eggs of Double-crested Cormorants (inshore, subsurface feeders), Leach's Storm Petrels (offshore, surface feeders) and Atlantic Puffins (offshore, subsurface feeders) were collected at four-year intervals from 1968 to 1988 from colonies in the Bay of Fundy (Kent, Machias Seal, and Manawagonish Islands), the estuary and Gulf of St. Lawrence (Ile-aux-Pommes, Ste Marie, and Carrousel), and on the open Atlantic coast (Great and Barasway Islands). Samples were analyzed at the Ontario Research Foundation and the National Wildlife Research Centre of the Canadian Wildlife Service for organochlorines, mostly pesticides, including DDT (DDE, etc.), PCBs, dieldrin, HCB, oxychlordane, heptachlor epoxide, HCH and mirex. This systematic monitoring program has provided one of the longest available data bases of its kind, facilitating determination of spatial patterns and trends in contaminants.

Results and Discussion. Early in the program, DDE posed a threat only to the cormorant, through reproductive effects via eggshell thinning. Since then, populations of that species have generally increased on Canada's east coast. Contaminant levels were generally not high enough to seriously affect the health of the seabirds sampled, although organochlorine burdens may influence the survival of birds during times of severe stress.

DDE and PCBs declined significantly in all species from the Bay of Fundy but levels now appear to have stabilized. On the Atlantic coast of Newfoundland, DDE declined in puffins and petrels while PCBs declined only in petrels. DDE has generally declined more than PCBs. Dieldrin, oxychlordane, HCH and mirex levels decreased at some sites but were stable at others. HCB and heptachlor epoxide levels remained steady or increased significantly, depending on the species and site. Organochlorine levels in cormorants from the St. Lawrence River estuary did not change between 1972 and 1984, indicating continued input but were generally lower in 1988. Likely contamination sources are discussed. Judging by trends in these marine birds, DDE, PCBs and dieldrin residue levels in the ecosystem of the eastern North American continental shelf have generally gone down in response to regulatory actions.

Continuation of this monitoring program is planned, to complement a similar program which addresses chemical contaminants in western Canadian seabirds.

For more information, contact:

P.A. Pearce
Canadian Wildlife Service
P.O. Box 400
Fredericton, N.B.
E3B 4Z9

(506) 452-3086

9. NEW BRUNSWICK SUBSURFACE DRAINAGE PROJECT: A STUDY OF EFFECTS OF INTENSIVE AGRICULTURAL PRODUCTION ON WATER QUALITY - (T.L. Pollock, H.J. O'Neill, P. Milburn, J.E. Richards, and C. Gartley)

Introduction. Elevated nutrient levels in surface waters from draining agricultural areas and chemical contamination from pesticide usage has been documented in several areas of North America. Pesticides may reach ground and surface waters via surface runoff, erosion, leaching, spray drift, improper container disposal and accidental spills. Large amounts of pesticides are used annually in the potato growing industry of the Atlantic Region. In co-operation with Agriculture Canada, and the New Brunswick Department of Agriculture, the Water Quality Branch (WQB), Atlantic Region, undertook a study of the presence of in-use pesticides in subsurface drainage from five potato fields in northeastern New Brunswick.

Methodology. Due to climatic conditions few pesticides were used in 1987. However, dinoseb (Dytop 300) was used as a pre-emergent herbicide or as a dessicant at some sites. Tile outflow was collected in the spring and during pre- and post-application rain events by lay collectors and quantitated for major ions and dinoseb. Dinoseb analysis was carried out using an *in situ* acetylation as developed by the National Water Research Institute (NWRI). During 1988 the triazine herbicide metribuzin was the active ingredient studied by the Branch.

Results and Discussion. The in-use pesticide dinoseb was observed in tile effluent from three potato fields in the spring of 1987 representing carry-over from 1986 applications. Levels ranged from 1.1 to 0.11 µg/L. One site indicated persistence of dinoseb for 11 months in the soil matrix. Dinoseb was also reported in post-application tile effluent with a single highest observation of 44.0 µg/L. Subsequent sampling until season end indicated diminishing dinoseb levels. Preliminary data from the spring of 1988 confirmed carry-over from the previous growing season and indicated trace level carry-over of 23 months at one study site. Major ion data indicated shifts in calcium, alkalinity, potassium, nitrate and total nitrogen concentrations as a result of fertilizer application.

Mass balance calculations indicate that the in-season sampling carried out by the Branch accounted for 0.001% of the dinoseb applied to two study fields.

In 1988 metribuzin was reported in concentrations ranging from 1.5 to 0.06 µg/L in tile effluent post-application. Carry over in the soil matrix wad confirmed by observations ranging from 0.14 to 0.30 µg/L in four samples collected in April of 1989.

This project was completed at the end of the 1989 fiscal year. An interim report is available and a final report will be prepared at project completion.

The results of this study provide the necessary regional background information to procceed with the second phase of the tile drainage work. A tile drained site in Southeastern N.B. flows into a small stream allowing the Branch to investigate water quality effects. Work was commenced on this site in late 1988-89 and is ongoing.

For more information, contact:

T.L. Pollock
Water Quality Branch
Atlantic Region
P.O. Box 861,
Moncton, N.B.
E1C 8N6

(506) 857-6606

10. GROUNDWATER PROGRAM, CANADA/PRINCE EDWARD ISLAND WATER MANAGEMENT AGREEMENT - (J. Gibb (Environment Canada), D. Jardine (P.E.I. Department of Environment))

Introduction. The Pesticides Project was conducted under the Groundwater Program of the Canada/PEI Water Management Agreement. This agreement, ran from April 1987 to March 1989; studied surface, ground, and estuarine water resources; and was implemented jointly by Environment Canada and the P.E.I. Department of Environment. The Pesticides Project was implemented in response to the heavy use of agricultural chemicals on the island and the reported occurrence of pesticides, such as aldicarb, in PEI groundwater.

The object of this project was to provide information on the nature and extent of pesticides in groundwater to facilitate the planning of future pesticide monitoring/use programs.

Methodology. About 150 wells for survey were selected to include wells considered highly susceptible to contamination: that is, shallow wells adjacent to and downslope from fields where selected pesticides were in use. The basis for pesticide selection included primarily use patterns and leaching potentials.

Results and Discussion. Although the results are still being evaluated, a small percentage of samples indicate the presence of traces of the insecticides phorate and disulfoton and the herbicides atrazine and metribuzin, which were all below drinking water guidelines. The occurrence of these pesticides and the coincidental discovery of an additional pesticide (the herbicide dinoseb), indicate that planning for future studies should include consideration of more comprehensive surveys.

For more information, contact:

John Gibb
Inland Waters
Conservation and Protection
Environment Canada
45 Alderney Drive
Dartmouth, N.S.

(902) 426-1698

11. PESTICIDE MIGRATION AND FATE IN GROUNDWATER - (R.E. Jackson, M.W. Priddle, P.A. Lapcevic, and A.S. Crowe (National Water Research Institute) and J.P. Mutch (Groundwater Studies Group, University of New Brunswick))

Introduction. In 1983 and 1984, surveys of domestic wells on Prince Edward Island (PEI) indicated that aldicarb contamination of groundwater was widespread; however, levels of contamination were low, less than the Canadian drinking water guideline (9 ppb). This pesticide, which is the active ingredient of Temik 10G, has been widely used to control aphids and the Colorado potato beetle on the PEI potato crop.

Methodology. A research project was initiated in 1985 by National Hydrology Research Institute (NHRI) and has been continued by the National Water Research Institute (NWRI) to determine the migration and fate of the aldicarb in order to learn more about the vulnerability of groundwater to pesticides. During the past five years the groundwater quality has been monitored beneath three fields to which aldicarb has been applied. The monitoring has been conducted by collecting groundwater samples from each of the 50 monitoring wells and three multilevel samplers installed at the field sites, plus one spring. The well points are completed in the fractured, Permo-Carboniferous sandstone which forms the sole source aquifer on Prince Edward Island. Chemical analysis of the samples was conducted at the NWRI (aldicarb) and at the Water Quality Branch Labs in Moncton, N.B. (nitrates and major ions).

Results and Discussion. The sampling campaign in July, 1989 yielded an average aldicarb concentration of 2.1 ppb per sample with a standard deviation of 1.8 ppb. These values are significantly lower than those from May 1988, when 10% of the samples collected contained total aldicarb concentrations >9 μg/L. This may reflect continued degradation of the aldicarb and also a seasonal effect in which the July concentrations are much lower than the May concentrations which reflect recent recharge of pesticide and fertilizer residues to the water table.

These results suggest aldicarb is being slowly transmitted through the unsaturated zone to the water table, where it is stored within the sandstone blocks. Once the pesticide is absorbed by the sandstone blocks, it is slowly degraded and subsequently slowly released to the flowing groundwater in the rock fractures thus maintaining trace aldicarb levels in the groundwater some three years after application.

Simulation of the migration of aldicarb to the shallow water table has been undertaken using the Cornell University computer code LEACHM (Wagenet, R.J., J.L. Huston, J. Env. Qual., 15(4):315-322 (1986)).

The system simulated at the University of New Brunswick was a 4-m soil profile with the water table initially set at 3 m in 1983. The validation involves adjusting dispersivity and rate constants to match observed field data. The one-dimensional code was not capable of simulating the three-dimensional processes involved in the migration and storage of the aldicarb residues; however, the derived rate constants suggested that the overall half life for aldicarb in the till/sandstone system is of the order of 150 days.

It appears that the safe use of aldicarb on PEI potatoes requires that the pesticide be applied at plant emergence, approximately late June, when soil temperatures are much higher than at planting in May and when ammonium fertilizer residues have had an opportunity to degrade.

For more information, contact:

Dr. Allan Crowe
National Water Research Institute
P.O. Box 5050
867 Lakeshore Rd.
Burlington, Ontario
L7R 4A6

(416) 336-4585

12. FEDERAL-PROVINCIAL DRINKING WATER SOURCES TOXIC CHEMICAL SURVEY - (Water Quality Branch, Atlantic Region Health Protection Branch)

Introduction. The 1988-89 fiscal year is the last of a four-year joint federal-provincial undertaking involving the Water Quality Branch (WQB), Health and Welfare Canada, the New Brunswick and Nova Scotia provincial departments of Health and the Prince Edward Island and Newfoundland departments of Environment. Ten percent of the population in Newfoundland, 70% in New Brunswick, 50% in Nova Scotia, and nearly all of Prince Edward Island depend upon groundwater for domestic purposes. This study involves the collection and analysis of raw surface and ground sources serving various municipalities in each Atlantic Province. Health and Welfare Canada is investigating various volatile organic materials in raw and treated water while the Water Quality Branch is interested in major ions, metals, nutrients, environmental contaminants and pesticides in raw water only.

Methodology. Ten municipal raw sources are sampled in each Atlantic Province in duplicate in the spring and the fall. Collection is carried out by WQB personnel in N.B., N.S. and P.E.I. and by provincial personnel in Newfoundland. Volatile organic samples are shipped to the Health and Welfare contract laboratory and all other samples are quantitated by the Analytical Services Division of the WQB. Volume of sample and preservation techniques are matched on a parameter-specific basis. Parameter selection is determined jointly and includes: major ions, metals, nutrients, chlorinated phenols, chlorinated benzenes, organochlorine insecticides, polychlorinated biphenyls, carbamate insecticides, organophosphorus insecticides, and polyaromatic hydrocarbons.

Results and Discussion. A data summary report has been prepared for each province for the 1985 and 1986 period, and for 1987. The ubiquitous organochlorine alpha-BHC and the polyaromatic hydrocarbon fluoranthene have been observed in several sources. Any pesticide observations for which Canadian Drinking Water Quality (1987) Guidelines exist, have been below the maximum acceptable concentration (MAC). Health and Welfare Canada have reported some volatile organic material in raw and treated sources. Perchloroethylene has been noted in two instances indicating an emerging area of concern. These locations were followed up by the provincial departments responsible. The aesthetic guideline for colour, has been exceeded by several municipalities that depend on surface water sources. Manganese and iron concentrations have also been reported in excess of the aesthetic guideline.

The 1988 fiscal year was the last year for this program in its current format. In 1989 the program focussed on pesticides and nutrients in Nova Scotia, chlorinated phenols in Newfoundland, and the full analysis in Prince Edward Island.

An interpretative report is in preparation.

For more information, contact:

D.H. Cullen
Water Quality Branch
Atlantic Region
P.O. Box 861
Moncton, N.B.
E1C 8N6

(506) 857-6606

13. AN APPLICATION OF SPANS TECHNOLOGY TO TOXIC CONTAMINANT MONITORING IN THE ATLANTIC REGION - (H.J. O'Neill and W.B. Hanna)

Introduction. Concern has increased over the presence of toxic organic chemicals including pesticides in the freshwater, bottom sediments, and biota of the Atlantic Region. Most environmental contamination is either a direct result of, or enhanced by, anthropogenic activity. It was felt that land use data could be used to identify areas of potential pesticide and contaminant input on a regional basis. Land activity information, however, has not been easily accessible to water resource managers and investigators in the past. The objectives of this study were to identify and rank areas of potential anthropogenic sources of contaminants based on land use data, to verify the resultant potential sources by use of existing Water Quality Branch data, and to illustrate how such information could be used as an information base during the design of monitoring networks and development of priority sites.

Methodology. All relevant data sets were obtained from the Canada Land Data System of Environment Canada and prepared for use. The micro-computer based SPANS geographic information system was used to conjugate land use information. It is generally accepted that the presence of certain factors in an area will increase the potential for higher levels of pesticides or contaminants. By identifying the areas in which these factors are prevalent, one may infer the existence of possibly higher toxic chemical loads. SPANS was used to conjugate land use information in order to produce a hypothesis map entitled "Potential Sources of Toxics". This map was tested using in-house data from the Water Quality Branch.

Results and Discussion. Two maps were generated through the conjugation of land use, land capability, industrial location, and demographic data bases. The "Potential Sources of Pesticides" map illustrates the potential sources of agricultural pesticides, while the "Potential Sources of Toxics" map illustrates known agricultural, industrial, and population factors. The use of a relative scale ranging from "Very High" potential to "Low" potential was employed to rank contaminant potential on a regional scale. An areal analysis of this map indicated that approximately 10% of the region fell into the "Very High" to "High" categories.

An examination of empirical data confirmed the general accuracy of this map. Of the 55 observations of toxic contaminants (PAH including fluoranthene, DDT, and PCB) ranked "High" and "Very High", 78% (43) were located in areas ranked "High" and "Very High" on the hypothesis map. Additionally, a strong correlation between potential pesticide input and observed nutrient levels supported the validity of the hypothesis map.

Monitoring networks for individual toxic contaminants may be enhanced by following the approach of this study. The occurrence of a toxic chemical in the environment is a function of many factors, but by converting information relevant to a specific toxin (contributing industries, soil types, etc.) into maps and conjugating them via matrix overlays, accurate predictive maps may be created. Making use of these maps (by identifying "hot-spots", etc.) will assist in selecting monitoring locations by eliminating some of the guesswork currently involved.

For more information, contact:

H.J. O'Neill
Water Quality Branch
Atlantic Region
P.O. Box 861
Moncton, N.B.
E1C 8N6

(506) 857-6606

14. ORGANIC CONTAMINANTS IN PRECIPITATION - (G.L. Brun, H.J. O'Neill, and G.D. Howell)

Introduction. Atmospheric transport, and subsequent deposition, has been recognized as a process which inputs organic contaminants to the terrestrial environment. It was proposed that atmospheric input is the principal mechanism for lindane and alpha-BHC presence in isolated lakes of southern Labrador.

The Water Quality Branch, Atlantic Region, has been collecting monthly composite wet precipitation samples at three main locations since 1980. Due to the sampling frequency and duration employed in this study, the ability to describe seasonal and temporal patterns was possible.

Methodology. Data from three sites was assessed using Box and Whisker plots for monthly and yearly analysis. Ordinal ranks of monthly medians were used to assess seasonal patterns. All parameters quantitated were assessed where positive observations were reported.

Results and Discussion. The presence of polycyclic aromatic hydrocarbons in wet precipitation has been shown to follow a seasonal pattern with higher concentrations being observed during the cold months of the year.

Concentrations at the three monitoring locations indicate local sources as the dominant mechanism.

Alpha-BHC and lindane observations at the three sites were virtually identical and in 1983 compared favorably with precipitation data from Lake Superior monitoring. The spatial similarities indicate that long-range transport is the dominant mechanism affecting the deposition of the hexachlorocyclohexane isomers.

For more information, contact:

G.L. Brun or H.J. O'Neill
Water Quality Branch
Atlantic Region
P.O. Box 861
Moncton, N.B.
E1C 8N6

(506) 857-6606

15. DISPERSION OF DICHLORVOS FROM A SIMULATED SALMON ECTOPARASITE CONTROL PROJECT - (W. Ernst and G. Julien)

Introduction. Dichlorvos is an acaracide which has been used in the Atlantic Region to control ectoparasites in finfish aquaculture. It is a pesticide which is extremely toxic to aquatic organisms with acute (96-h LC_{50}) lethal effects to lobster larvae occurring at approximately 6 µg/L. Zooplankton mortality has occurred at concentrations as low as 1 µg/L and primary productivity has been measurably reduced to concentrations of 14 µg/L. The use pattern in aquaculture can be classed as "open", resulting in the release to marine environments of all the pesticide solutions used for treatment. Since the fate of the pesticide after such use is largely unknown, a study was undertaken to measure the dispersion characteristics in a marine situation.

Methodology. The circulation patterns of a small coastal inlet were determined by means of: dye and drogue tracking, as well as measurement of currents, salinity and temperature with depth. Dichlorvos was subsequently released at concentrations and depths to mimic treatment of a large number (50 to 80) of salmon pens. Based on dispersion predictions from the circulation characteristics, grab samples at several depths were obtained at various times after release and at various distances from the release point. Those samples were analyzed for dichlorvos content.

Results and Discussion. The highest concentrations of dichlorvos (32 µg/L) were measured at the release site within 15 minutes of release. At 90 and 100 minutes post-release the highest concentrations were 5.7 and 2.4 µg/L, respectively. By 300 minutes post-release, the highest measured concentrations were near the detectable limit of 0.1 µg/L. The chemical plume was observed to spread over a broad area (approx. 1 km) and to penetrate a moderate thermocline to a depth of 5.5 m. The measured concentrations are within the range known to be toxic to planktonic organisms and the environmental implications of such use could be severe.

For more information, contact:

W.R. Ernst
Environmental Protection
Conservation and Protection
Environment Canada
15th Floor, Queen Square
45 Alderney Drive
Dartmouth, N.S.
B2Y 2N6

(902) 426-6141

16. TRANSPORT AND EFFECTS OF AERIALLY APPLIED CHLOROTHALONIL IN A SMALL POND - (H.J. O'Neill and W. Ernst)

Introduction. Chlorothalonil is a fungicide that is extensively used in the Maritime Provinces to combat potato blight. A Water Planning and Management Branch document placed chlorothalonil on a Priority II list due to its high use and soil persistence. Chlorothalonil has been shown to be toxic to fish with LC_{50}s of 0.39 mg/L, 0.25 mg/L, and 0.43 mg/L for bluegill, rainbow trout, and channel catfish, respectively. Environment Canada, Conservation and Protection, Altantic Region, submitted a PESTFUND proposal to investigate the aquatic effects and transport of chlorothalonil in actual use and mis-use scenarios. The Water Quality Branch focussed upon the environmental presence and transport, while Environmental Protection centered on biological responses.

Methodology. A small water course, typical of Prince Edward Island, in the Cape Traverse area was selected as the most appropriate study site. A small pond 15 x 20 m lay between two potato fields and was suitable for study purposes. Three separate oversprays were employed in order to represent worst case mis-use. Field sampling of both water and suspended materials was conducted during two oversprays.

Results and Discussion. A maximum aqueous concentration of 452 µg/L was observed. This concentration was above the aforementioned LC_{50}s. However within 12 hours of overspray the concentrations were below 10 µg/L. Under operational conditions, in this lotic system, resident biota would have been exposed to maximum concentrations for approximately 10 minutes. Though no chlorothalonil residues were reported in bottom sediments, the suspended component of the water column leaving the sprayed pond was found to contain chlorothalonil.

The Water Quality Branch results have been combined with the biological component of Environmental Protection.

For more information, contact:

H.J. O'Neill
Water Quality Branch
Atlantic Region
P.O. Box 861
Moncton, N.B.
E1C 8N6

(506) 857-6606

PESTICIDES PROGRAM IN THE QUEBEC REGION

1. LEACHING OF METOLACHLOR, ATRAZINE, AND ATRAZINE METABOLITES IN SOIL AND GROUNDWATER - (P.-Y. Caux, S. Prasher, and L. Masse)

Introduction. Atrazine and metolachlor have been the subject of many laboratory, greenhouse, and field studies in the United States and in Southern Ontario. Little research, however, has been conducted in Quebec, where cold weather for the greater part of the year could prolong the life of herbicides by preventing degradation. Quebec soils also exhibit highly varying water table depths. The water table generally remains close to the soil surface in the spring but often drops to more than 3 m below the soil surface in the summer. The rapid downward movement of soil water could enhance leaching of any residual chemicals in the field. This could raise the possibility of groundwater contamination as atrazine and its phytotoxic dealkylated metabolites have been shown to persist in some soils; in some cases, beyond the growing season (Burnside *et al.*, 1969; Khan and Marriage, 1977; Muir and Baker, 1976; Ritter *et al.*, 1987). The influence of climatic conditions on herbicide behaviour in soils requires that experiments be conducted in the different regions where the herbicide is used by farmers. Walker and Zimdhal (1981), for example, have determined that metolachlor was less persistent than atrazine in Mississippi while the opposite was found in northern New York State.

Corn is a predominant crop in Quebec and atrazine is the most widely used herbicide on corn fields. The problem of carry over of phytotoxicity of this persistent herbicide and of its dealkylated metabolites often prevents crop rotation. Metolachlor, on the other hand, can be used on different bean crops, as well as on corn, and could thus be applied in conjunction with reduced doses of atrazine where crop rotation is part of the management system. Groundwater loading of metolachlor, however, remains to be determined in the northern regions before its use becomes widespread.

This research aimed at evaluating the persistence and the movement of metolachlor and atrazine, including its metabolites, in soil over a five-month period. It also aimed at assessing the groundwater contamination potential of the herbicides by monitoring groundwater in corn fields during the sampling period. Two different soil types, a clay and a sand, were selected in order to compare the leaching potential of the two herbicides in a heavy and in a light textured soil under Quebec climatic conditions.

Methodology. A field study was undertaken during the summers of 1988 and 1989 to investigate leaching characteristics of metolachlor, atrazine, and atrazine metabolites in two agricultural soils of Quebec, namely a St. Amable sand and a St. Laurent clay.

Results and Discussion. In 1988, in both field, atrazine concentrations were reduced by half the original levels in less than two weeks. A half-life persistence was also less than two weeks for metolachlor in the clay field but was slightly over 3 weeks in the sandy field. The difference is probably due to different application times in the two fields. Atrazine was detected at higher levels in the clay field than in the sandy field, both in groundwater and at depths below 20 cm in the soil while metolachlor levels were below detection limits in the groundwater of both fields. Deethylatrazine, the only metabolite found in soil, was present in higher levels in the clay field even though microbial degradation of atrazine was overall minimal. In the groundwater zone, deisopropylatrazine was the only detected metabolite and concentrations were similar in both fields. The analysis of the metabolites seems to indicate that the transformation of atrazine into deisopropylatrazine occurs in saturated conditions while, in the unsaturated zone, deethylatrazine is the major degradation product. It could also reveal a higher leaching potential for deisopropylatrazine than for deethylatrazine. The Canadian fresh water aquatic life guideline for atrazine of 2 µg/L, was exceeded shortly after application and from August to the end of the sampling period in October in the groundwater of the clay field while leaching to the groundwater in the sandy field was minimal. The 1989 results are being analyzed.

References

Burnside, O.C., C.V. Fenster, G.A., Wicks, and J.V. Drew, "Effects of Soil and Climate on Herbicide Dissipation," Weed Sc., 17:241-244 (1969).

Khan, S.U. and P.B. Marriage, "Residues of Atrazine and its Metabolites in an Orchard Soil and their Uptakes by Oat Plants", J. Agric. Food Chem., 25(6):1408-1413 (1977).

Muir, D.C. and B.E. Baker, "Detection of Triazine Herbicides and Their Degradation Products in tile-drain Water from Fields Under Intensive Corn (maize) Production", J. Agric. Food Chem., 24(1):122-125 (1976).

Ritter, W.F., A.E.M., Chirnside, and R.W. Scarboraugh, "Pesticide Leaching in Irrigated Corn," ASAE, St. Joseph, MI, NAR 87-202 (1987).

Walker, A., and R.L. Zimdhal, "Simulation of the Persistence of Atrazine, Linuron, and Metolachlor in Soil at Different Sites in the USA," Weed Res., 21:255-265 (1981).

For more information, contact:

Dr. Pierre-Yves Caux
Centre Saint-Laurent
Division de l'hydrologie et des réseaux
1001, rue Pierre-Dupuy
Longueuil, Québec
J4K 1A1

(514) 646-6043

Dr. Shiv Prasher
Agricultural Engineering
MacDonald College of
McGill University
Sainte-Anne-de-Bellevue, Québec
H9X 1C0

(514) 398-7773

Lucie Masse
Agricultural Engineering
MacDonald College of
McGill University
Sainte-Anne-de-Bellevue, Québec
H9X 1C0

(514) 398-7773

2. CHANGES IN INTRACELLULAR FREE AMINO ACIDS (FAA) IN CAGED MUSSEL, *Elliptio complanata*, IN AGRICULTURAL WATERSHEDS

- (Kristin E. Day, Janice L. Metcalfe, and Suzanne P. Batchelor - N.W.R.I., Burlington, Ontario)

Introduction. The detection of biochemical changes at the molecular and cellular level of organization in organisms exposed to chemical contaminants may be the earliest and most sensitive indication of a toxic response. These changes may in turn be indicative of decreases in the survival, growth and/or reproduction at the population and community level of organization. One such biochemical tool is the measurement of changes in intracellular tissue concentrations of free amino acids (FAA) in molluscs. Total concentrations of FAA in marine organisms have been shown to decrease following exposure to toxic chemicals, but studies with freshwater organisms are rare.

The objective of this research was to monitor the FAA pool of the freshwater mussel, *Elliptio complanata*, exposed *in situ*, in cages, to stressful environments in tributaries of the Yamaska River, Quebec, and to determine if changes occur in the FAA pool as a consequence of stress. The Yamaska River basin is known to be contaminated with a number of chemical pollutants, including pesticides, and the study sites in this project included several stations where nutrient and pesticide runoff from agricultural farmland was prevalent.

Methodology. Caged mussels (*Elliptio complanata*) were placed at several sites in the Yamaska River watershed during the summer of 1987 close to sources of agricultural runoff. Caged mussels were also placed in sites considered to be pristine. After 27 to 29 and 77 to 79 days of exposure, mussels were removed from cages at each of the sites, frozen, and returned to the laboratory for analysis of levels of free amino acids in the mantle, gill, and adductor muscle tissues using high pressure liquid chromatography (HPLC).

Results and Discussion. Total concentrations of FAA (nmol/mg wet weight) increased above background or control levels in both mantle and adductor muscle tissue at sites affected by agricultural runoff. These same sites were classified as poor to very poor in water quality using a biotic index for benthic invertebrate community health. Increases in total FAA levels could be attributed to increases in almost all individual FAA. Consistent changes in the % composition of individual FAA to the total FAA pool included decreases in serine, threonine, glycine, and valine as well as increases in glutamic acid and glutamamine. Few changes in total or individual FAA were observed in gill tissue. These results are similar to those reported in other studies on freshwater organisms and suggest that increases in total FAA in some tissues of freshwater bivalves may be indicative of generalized stress and may be a useful biomonitoring technique for future use by Environment Canada to assess *in situ* toxicity from non-point source pollutants.

A full report can be found in NWRI Contribution #89-104.

For more information, contact:

Dr. Kristin Day
National Water Research Institute
P.O. Box 5050
867 Lakeshore Rd.
Burlington, Ontario
L7R 4A6

(416) 336-4659

3. DEVELOPMENT OF A SITE-SPECIFIC WATER QUALITY OBJECTIVE FOR ATRAZINE IN THE YAMASKA RIVER - (P.-Y. Caux, M. Wong, R.A. Kent, and M. Taché)

Introduction. Photosynthetic activity, which is directly related to electron transport in photosystem II (PSII), is measured by the fluorescence emitted by the plant tissue and calculated as the difference in the P-T transient [1,2].

The use of a fluorometer [3] is a rapid and effective method for determining the relative toxicity of environmental pollutants. We know that photosynthetic inhibitors (herbicides) increase chlorophyll fluorescence due to dissipation of absorbed radiant energy emitted in the presence of defective photochemistry. The transient changes in chlorophyll fluorescence following the onset of lumination of dark-adapted leaf tissue are representative of the total fluorescence value obtained with the fluorometer [4-7,2]. The changes in fluorescence induction are associated with damage to the water-splitting site of the Hill reaction (PS II site). This may lead to a reduction in the effectiveness of the primary electron acceptor which, in turn, inhibits electron transport between PSII and PSI.

The physical/chemical composition of different bodies of water may alter the potential toxicity of a pesticide. Therefore, it should be determined whether variances in physical/chemical composition affects the toxicological effects of a given concentration of pesticide. By determining the relationship between the toxicological effects and physical/chemical parameters of tributaries of the same or different rivers, it may be possible to predict the behaviour of the pesticides in a given hydrologic system.

Methodology. **Atrazine Treatment:**
Selenastrum capricornutum: A 50-mL water sample was filtered through a 0.45-µm Millipore filter into a 250-mL sterile Erlenmeyer flask to eliminate the algae present; 0.05 mL of a nutrient medium was added. The cultures were treated with atrazine concentrations of 2 and 20 µg/L. These samples were inoculated with 0.5 mL of a *Selenastrum capricornutum* culture and incubated for 8 to 10 days.

Lemna minor: A 50-mL water sample was passed through a 0.45-µm Millipore filter into a sterile 250-mL Erlenmeyer flask. Nutrients were added to the system. The medium was then inoculated with a single plant. Atrazine was added to each system in the same concentrations as the *Selenastrum capricornutum*. The flasks were then incubated at 25°C with no agitation at a light intensity of 95 $\mu E/m^2 \cdot s^{-1}$ for 8 to 10 days.

Natural algae assemblage: A 50-mL sample of water in a 250-mL Erlenmeyer flask was enriched with a nutrient medium. Atrazine was added in the same concentrations as above. The samples were incubated under the conditions described above for 10 to 12 days.

Each of these experiments were performed in triplicate.

Fluorometric Analyses: A SF-30 fluorometer (Richard Brancker Inc., Ottawa) was used to measure fluorescence induction, a sensitive indicator of photosynthetic activity. The fluorometer was set at a gain of 0.8 and at a light exposure of 50 seconds, giving a maximum light intensity of 10^4 $ergs/cm^2 \cdot s^{-1}$.

After the atrazine treatment, a 15- to 30-mL treated sample was filtered under vacuum through a Whatman GF/C glass fibre filter. The filter was then placed on top of two Whatman No. 1 filter papers pre-moistened with the medium. The fluorometer probe was centred on top. In order to allow the cells to readapt to the dark, the probe was left on the filter for exactly three seconds.

After each reading, the filters were oven-dried at 80°C for approximately one hour. The dry weight of the algae was determined gravimetrically.

Results and Discussion. A typical flurometric response of an untreated sample of alga culture shows the peak (P), characteristic of photosynthetically active cells. The fluorescence curve measured shows different stages coming from several photo-reactional centres (8). The

letter "T" designates the termination of peak "P". The length of the P-T transient was used to quantitate photosynthetic activity. The value obtained is then expressed in the percentage of inhibition as compared to a control value.

The results are presently undergoing statistical analysis and will be presented in a report and/or scientific publication.

References

1. Shreiber, U., W. Vidaver, V.C. Runeckles and P. Rosen, "Chlorophyll Fluorescence Assay for Ozone Injury in Intact Plants", Plant Physiol., 61: 80-84 (1978).

2. Moody, R., P. Weinberger, and R. Greenhalgh, "Algal Fluorometric Determination of the Potential Phytotoxicity of Environmental Pollutants", In: Aquatic Toxicology, J.O. Nriagu (ed.), John Wiley, New York, pp. 503-412 (1983).

3. Moody, R., "Algicidal Activity of Formulated Fenitrothion. The Effect of Cosolvent, Aerotex 3470 on Unicellular Algae", Ph. D. thesis, University of Ottawa, Canada (1982).

4. Ahrens, W.H., C.J. Arntzen, and E.W. Stoller, "Chlorophyll Fluorescence Assay for the Determination of Triazine Resistance", Weed Sci., 29: 316-322 (1981).

5. Kaustsky, H. and A. Hirsch, "Neve Versuche zur Kohlensaure Assimilation", Naturwissenschaften, 19: 964 (1931).

6. Govindjee and C. Papageorgiou, "Chlorophyll Fluorescence and Photosynthesis: Fluorescence Transients," In: Photobiology, 6, pp. 1-46 A. Giese (ed.), Academic, New York, (1971).

7. Schreiber, U., L. Groberman, and W. Vidaver, "Portable Solid-state Fluorometer for the Measurement of Chlorophyll Fluorescence Induction in Plants," Rev. Sci. Instrum., 46: 538-542 (1975).

8. Papageorgiou, C., "Chlorophyll Fluorescence: An Intrinsic Probe of Photosynthesis", In: Bioenergetics of Photosynthesis, Govindjee (ed.), Academic Press, New York, pp. 319-371 (1975).

For more information, contact:

Dr. Pierre-Yves Caux
Centre Saint-Laurent
Division de l'hydrologie et des réseaux
1001, rue Pierre-Dupuy
Longueuil, Québec
J4K 1A1

(514) 646-6043

Michel Taché
Centre Saint-Laurent
Division de l'hydrologie et des réseaux
1001, rue Pierre-Dupuy
Longueuil, Québec
J4K 1A1

(514) 646-6043

Mike Wong
Inland Water Directorate
Water Quality Branch
Ottawa, Ontario
K1A 0H3

(819) 953-3197

Robert Kent
Environmental Protection
Environmental Analysis Branch
Ottawa, Ontario
K1A 0H3

(819) 953-7703

4. A TWO-COMPONENT INVESTIGATION ON THE EFFECTS OF PESTICIDES ON THE BIOTA (PHYTOBIOLOGY) OF A RIVER IN A WATERSHED SUBJECT TO INTENSE AGRICULTURAL ACTIVITY - (P.-Y. Caux and M. Taché)

Introduction. The use of pesticides has engendered potential ecotoxicity for different terrestrial and aquatic organisms (Matsumura *et al.*, 1972). A compilation of the principal pesticides in current use in Quebec (Sage, 1988) has enabled sounder design in the monitoring and sampling techniques used in both spatial and temporal applications.

Two of the three objectives established have been partially achieved by developing an evaluation and monitoring program for pesticides commonly used in Quebec, and providing managers with information on the presence and fate of pesticides in the environment. The third objective was to provide a data base for the re-evaluation of the use of pesticides.

The first and second objectives were achieved through recent studies conducted on at least six tributaries of the St. Lawrence River representing watersheds characterized by intense agricultural activity.

The pesticides identified to be of concern were: atrazine (maximum concentration (MC) 20.7 µg/L, guideline 2 µg/L; diazinon (MC 18 µg/L); 2,4DB (MC 4.6 µg/L, guideline 4.0 µg/L); lindane (MC 0.1 µg/L, guideline 0.01 µg/L); p,p'-DDE (MC 0.014 µg/L, guideline 0.003 µg/L); alpha-endosulfan (MC 0.02 µg/L, guideline 0.003 µg/L); and beta-endosulfan (MC 0.035 µg/L, guideline 0.003 µg/L). These pesticides are among those to which priority has been given by the Food Production and Inspection Branch (see: document R-1-226).

The acquisition of data required to re-evaluate the use of pesticides for their eventual re-registration has, however, not been done. This problem is not unique to the Quebec Region, but is one which has national repercussions. Today's pesticides are less persistent and are used, in principle, in accordance with application standards. Further, it is advantageous for farmers to practice integrated pest management techniques. Efforts to obtain data should attempt to answer the question of whether these spatially and temporally detected levels of toxicants have an effect on organisms and ecosystems. The following is the brief design of a two component experiment aimed at measuring the spatial and temporal effects on phytoplankton and macrophytes.

Methodology. The organisms selected are sensitive, non-target, and representative of the aquatic ecosystems. These organisms occur throughout Canada. The criteria defining the choice of bioassays were: pertinency to current knowledge on pesticide mode of action, availability, costs, rapidity and applicability to the field situation (in situ). The results obtained from these experiments will signal, in a statistically valid manner, the existence or lack of effects at a specified level.

Organisms: two organisms were selected:

1) *Lemna minor*

2) Algae (from the environment or *Selenastrum*)

Bioassays: four in all

1) biomass (dry and wet weight, number)

2) bioaccumulation

3) microplates

4) lipid content/composition

Results and Discussion. The first component of the experimental design was a follow-up of the collection of data on pesticides identified as being of concern in the region. The results of these analyses have not yet been obtained and will be presented in a study report.

The second component of the experimental design will address the laboratory temporal effects of five pesticides on selected organisms. Several

concentrations, including those measured in situ will be used. The pesticides to be analyzed are atrazine, diazinon, 2-4-DB, lindane, and endosulfan.

Each organism will be treated separately and kept in axenic conditions. Following a two-week treatment period, biomass and fluorometry measurements will be taken. The analyses of bioaccumulation and lipid content/composition will be contracted out. The laboratory tests will provide the preliminary data needed for field testing.

The second component of the experimental design will also perform the same bioassays on existing plant communities in the aquatic ecosystems to include the chosen test organisms.

A part of these experiments will begin in early October and will continue throughout 1990. To date, microplate results have been taken to assess the effect of atrazine on the green alga *Selenastrum*. These results are presently undergoing statistical analysis and will be presented in a report or scientific publication.

References

Matsumura, F., G.M. Boush, and T. Misato, Environmental Toxicology of Pesticides, Academic press, New York and London, 637 p. (1972).

Sage Ltée, Recueil des principaux pesticides en usage au Québec, Cossette D., Giroux, I. et Poulin, R. (eds.), Sage Ltée, 4700, boul. Wilfrid-Hamel, Québec, Québec, GIP 2J9 (1988).

For more information, contact:

Dr. Pierre-Yves Caux
Centre Saint-Laurent
Division de l'hydrologie et des réseaux
1001, rue Pierre-Dupuy
Longueuil, Québec
J4K 1A1

(514) 646-6043

Michel Taché
Centre Saint-Laurent
Division de l'hydrologie et des réseaux
1001, rue Pierre-Dupuy
Longueuil, Québec
J4K 1A1

(514) 646-6043

5. EVALUATION OF THE MEDIUM-TERM EFFECTS OF THE USE OF PHENOXYS AND GLYPHOSATE ON BIRD POPULATIONS IN BLACK SPRUCE PLANTATIONS - (Brigitte Hardy, Environnement Illimité Inc; Jean-Luc DesGranges, Canadian Wildlife Service, Quebec Region)

Introduction. The main objective of this study was to assess the medium-term effects (seven to nine years) of the treatment of black spruce plantations (*Picea mariana*) with phenoxys (Estaprop) and glyphosate (Roundup) on bird populations during reproduction in the lower St. Lawrence and Gaspé regions of Quebec. The study covered four plantations in which breeding bird populations were inventoried in the spring of 1988; the characterization of the vegetation of these plantations was carried out in the summer of 1988.

In the Lower St. Lawrence region, the study focussed on a black spruce plantation established in 1980 and treated with glyphosate in 1981; a natural regeneration area was used as a control environment. In the Gaspé, the plantation used was established in 1976 and was treated with phenoxys. One untreated plantation was available as a control environment.

Methodology. The inventory of bird species was conducted using the point count technique (PCT). Twenty sampling points were established in each plantation; these points were inventoried three times in early morning and once at the end of the day, in order to inventory all species of nesting birds. The vegetation of each sampling point was characterized within one or more representative quadrats.

Results and Discussion. In the lower St. Lawrence region, 26 bird species were inventoried in the treated plantation and 28 in the natural regeneration area. Nine species showed significantly higher densities ($p<0.05$ or $p<0.001$) in areas in which the glyphosate treatment was applied, in comparison to one for natural regeneration areas. The species diversity and dominance indices, as well as the mean number of species and pairs per sampling point, were higher in the plantation.

In the Gaspé, 26 species were inventoried in the treated plantation, compared to only 17 in the untreated plantation. Five species had higher densities in the sites treated with phenoxys ($p<0.05$); however, six species showed significant negative differences, being less abundant, and even absent, from the treated plantation. The average number of bird species per sampling point is virtually the same as in each of two plantations, whereas the number of pairs and the diversity index are higher in the treated plantation. The dominance index, however, is higher in the untreated plantation.

The plantations treated with herbicides show a greater conifer cover and more substantial clearing than in the control stands. The untreated plantation is invaded by hardwood species and has dense crown cover. These changes in habitat cause a significant increase in the density of several species of nesting birds, as well as an increase in species diversity, owing to the mixed nature of the stands after seven to nine years of herbicide treatments. In the medium-term, therefore, the use of herbicides appears to be beneficial to bird populations.

Reference

Hardy, B. and J.L. DesGranges, "Évaluation des effets à moyen terme sur les communautés aviennes de l'entretien des plantations d'épinettes noires (*Picea mariana*) aux phénoxys (Estaprop) and au glyphosate (Roundup)," Environnement Illimité Inc. for Environment Canada, Technical Report, Canadian Wildlife Service, Quebec Region, 26 pp + appendices (1989).

For further details, contact:

Jean-Luc DesGranges
Canadian Wildlife Service
P.O. Box 10100
Sainte-Foy, Quebec
G1V 4H5

6. EFFECTS OF THE APPLICATION OF AZINPHOS-METHYL, MALATHION, AND CARBOFURAN ON NESTING BIRDS IN APPLE ORCHARDS AND STRAWBERRY FIELDS IN QUEBEC - (Douglas Graham and Richard Poulin, SAGE Ltée; Jean-Luc DesGranges, Canadian Wildlife Service, Quebec Region)

Introduction. The objective of this study, which was conducted in southern Quebec, was to identify the possible effects on birds of three insecticides commonly used on strawberry fields (malathion and carbofuran) and in orchards (azinphos-methyl).

Methodology. The experimental methods consisted of the determination of mortality due directly to the use of a pesticide, the observation of the effects on physiology and behaviour, and the assessment of effects on populations on the basis of territorial behaviour and nest density.

Results and Discussion. No effects were observed in the case of malathion. With respect to carbofuran, the small size of the sample did not enable the observation of measurable effects. Azinphos-methyl may be the cause of the cholinesterase inhibition observed in birds frequenting the orchards; except for this possible exposure to the pesticides, no other effect was observed or detected.

An attempt is made in the report to explain the causes for the absence of measurable effects with each method used. The potential harmful effects of the insecticides examined in this study are evaluated for other types of crops in Quebec.

Reference

Graham, D., R. Poulin and J.L DesGranges, "Effets de l'arrosage de l'azinphos-méthyl, du malathion et du carbofuran sur les oiseaux nicheurs des pommeraies et des fraiseraies au Québec, SAGE Ltée for Environment Canada, Technical Report, Canadian Wildlife Service, Quebec Region, 63 pp. + appendixes (1989).

For further details, contact:

Jean-Luc DesGranges
Canadian Wildlife Service
P.O. Box 10100
Sainte-Foy, Quebec
G1V 4H5

7. EFFECTS OF THE TREATMENT OF ORNAMENTAL TREES WITH DIAZINON AND ACEPHATE ON THE AMERICAN ROBIN IN URBAN AREAS - (François Morneau and Robert Décarie, GREBE Inc; Jean-Luc DesGranges, Canadian Wildlife Service, Quebec Region)

Introduction. The objective of the study was to determine whether acephate (Orthene) and diazinon (Basudin), two insecticides used on ornamental trees in urban areas, have lethal or sublethal effects on bird populations. Acephate is used primarily to control budworms in conifers, while diazinon is used to control aphids in fruit trees.

Methodology. The effect of these products was tested on the feeding and brooding behaviour and on the productivity of the American robin (*Turdus migratorius*). Roughly 100 American robin nests were divided into three groups: a control group, a group treated with acephate, and a group treated with diazinon. In the treated groups, with very few exceptions, only the trees containing nests were sprayed.

Results and Discussion. No mortality of adult nesting birds was observed, each brood having continued its development. The results indicate that there are no significant differences in the productivity of the two groups. It should be noted that productivity is the number of nestlings still alive after 11 days, whereas the reproductive success of a nest is the ratio of the number of nestlings produced to the number of eggs laid. Reproductive success could not be compared between the two groups because the clutch size was known for only a few of the nests. The number of feeding trips, the number of fecal sacs eliminated by the adults, and brooding by the female were not significantly affected. However, productivity and the number of feeding trips were lower in the group treated with diazinon. Analyses of acetylcholinesterase activity were not conclusive. It has been suggested that the absence of effects could be due to: (1) the very localized nature of the treatment and to the small doses used; (2) the fact that to have an effect, exposure to the products must be considerable or the products must be ingested; and (3) the fact the American robin feeds over a vast area which substantially exceeds the very limited area covered by the sprayed nesting area. With regard to diazinon, it is possible that the sample size was not large enough to detect a moderate effect.

Reference

Morneau, R., R. Décarie and J.L. DesGranges, "Effets du traitement des arbres ornementaux au diazinon (BASUDIN) et à l'acéphate (ORTHENE) sur le Merle d'Amérique (*Turdus migratorius*) en milieu urbain, GREBE Inc. for Environment Canada, Technical Report, Canadian Wildlife Service, Quebec Region, 50 pp. + appendices (1989).

For further information, contact:

Jean-Luc DesGranges
Canadian Wildlife Service
P.O. Box 10100
Sainte-Foy, Quebec
G1V 4H5

PESTICIDES PROGRAM IN THE ONTARIO REGION

1. FEDERAL INTERDEPARTMENTAL QUALITY ASSURANCE ON PESTICIDE ANALYSIS - (Yvonne D. Stokker and A.S.Y. Chau)

Introduction. Reference sample extracts are extremely useful materials in both intra- and interlaboratory quality assurance/quality control (QA/QC) as well as for method validation and research. The availability of such reference materials along with suitable standard solutions in ampoules could reduce the cost and increase the effectiveness of laboratory quality control and analysis in monitoring and surveillance programs. This study undertook to produce some unique reference materials in the form of sediment extracts in ampules for atrazine and other s-triazine herbicides of concern. The design values, homogeneity and stability of these herbicides were confirmed by both in-house analyses as well as in an interlaboratory QC study.

The objectives of this study were:

(a) to generate the reference extracts in ampules;

(b) to verify the design values and monitor the homogeneity and stability of these samples; and

(c) to conduct one interlaboratory QC study on the analysis of s-triazines in the sediment extracts.

The purpose of the QC study was to monitor the laboratories and methodologies that contribute to the database for these herbicides and, by so doing, establish the degree of confidence and comparability in the data upon which management decisions are made (e.g., regulatory control of Atrazine in environmentally sensitive locales).

Methodology. A 5.0 kg sample of freeze-dried sediment from Lake Erie and Lake St. Clair was crudely extracted with acetone to provide the co-extractives necessary as background for the sediment reference material in this study. After filtering, the extract was split and fortified to two levels with atrazine, simazine, propazine and cyanazine. "Standard" solutions were also prepared at similar concentration ranges and sealed into glass ampoules alongside the reference sediment extracts. Homogeneity of these materials was verified immediately, while stability testing is still continuing.

For the interlaboratory QC study, more than 30 Canadian laboratories received sample sets consisting of four ampules containing the sediment extracts along with seven different mixtures of the "standard" solutions in ampules.

Results and Discussion. All objectives of this study were successfully completed. Homogeneity was confirmed between the ampules and stability of the four s-triazines of interest was verified for up to six months and is still being monitored. In all, close to 1000 ampules containing the sediment extracts remain.

The quality control study using these sediment extracts was conducted under the auspices of the National Program of QC Studies. Twenty-two laboratories submitted results for the four s-triazines in the eleven ampules. The interlaboratory medians from the submitted results agreed quite well with the design values for each s-triazine, thereby offering support to the verification of the design values. Although there were a few outlying results in this QC study, the majority of participants produced very good data. Thus it appears that one may place considerable confidence in the s-triazine data being generated by these same laboratories in their monitoring programs.

For more information, contact:

Yvonne D. Stokker
Environment Canada
Quality Assurance, RAB
867 Lakeshore Rd.
Burlington, Ontario
L7R 4A6

(416) 336-4638

2. CANADIAN WATER QUALITY GUIDELINES FOR ATRAZINE, CARBOFURAN, AND GLYPHOSATE - (CCME)

Introduction. The Canadian Council of Ministers of the Environment (CCME, formerly the CCREM, Canadian Council of Resource and Environment Ministers) has identified the development of Canadian Water Quality Guidelines for in-use pesticides as a priority. This procedure has been completed for the herbicides atrazine and glyphosate, and the agricultural acaricide, nematicide and insecticide, carbofuran.

Methodology. Data regarding the aquatic toxicology, environmental concentrations, environmental fate and persistence, and the physical and chemical characteristics of these three compounds were gathered from the world literature and critically reviewed. Where the available data permitted, Canadian Water Quality Guidelines for the five major water uses - raw water for drinking water supply, recreation and aesthetics, freshwater aquatic life, irrigation water and water used for livestock watering were recommended. The information and guidelines were reviewed and approved by the Task Force on Water Quality Guidelines. Following this process, the Canadian Water Quality Guidelines listed in the following table were recommended.

Results and Discussion. Following the review process, the Canadian Water Quality Guidelines listed in the following table were recommended.

The scientific and technical information regarding these three pesticides are contained in the CCME summary and will be published as a supplement to the 1987 Canadian Water Quality Guidelines document.

CANADIAN WATER QUALITY GUIDELINES FOR ATRAZINE, GLYPHOSATE AND CARBOFURAN

	Atrazine	Glyphosate	Carbofuran
		(μg/L)	
Raw Drinking Water*	60	280	90
Freshwater Aquatic Life	2	65	1.75
Recreation and Aesthetics	--	--	--
Irrigation	10	--	--
Livestock	60	280	45

* Existing drinking water guidelines (Federal-Provincial Subcommittee on Drinking Water)

For more information, contact:

Robert Kent
Water Quality Objectives Division
Water Quality Branch
Ottawa, Ontario
K1A 0H3

(819) 953-1554

3. SCREENING TECHNIQUE FOR THE DETECTION OF ATRAZINE IN SURFACE AND GROUNDWATER - (James P. Sherry)

Introduction. Conventional methods for the analysis of trace organic contaminants in environmental samples are generally time consuming and expensive. Often, many contaminant free samples must be extracted and cleaned up before being analyzed using GC or GC/MS. The inclusion of screening steps in analytical protocols would, by the elimination of contaminant free samples from subsequent analysis, greatly reduce analytical costs. Samples that test positive using the screening assay would be confirmed and quantified using conventional methods. Of the available screening tests, immunoassays (IA) appear to offer the most promise.

Based on the classical antigen-antibody reaction, IAs are relatively simple, powerful and adaptable techniques for the rapid detection of trace levels of organic compounds. Originally developed for the micro-determination of proteinaceous substances, they are now extensively used in the detection and determination of steroidal hormones and other low molecular weight organic molecules. IAs have been proposed for the detection of a wide range of pollutants including, polychlorinated dibenzo-*p*-dioxins (PCDDs), polychlorinated biphenyls (PCBs), dieldrin and aldrin; 2,3,7,8-tetrachlorodibenzofuran (TCDF), diclofop-methyl, 2,4-dichlorophenoxyacetic acid (2,4-D) and 2,4,5-trichlorophenoxyacetic acid (2,4,5-T). The International Union of Pure and Applied Chemistry, reporting on improved and cost effective approaches to pesticide residue analysis, concluded that immunochemical methods, while being traditionally unfamiliar to the residue chemist, offer exciting possibilities for newer, cost effective approaches. Most IAs cost just a few dollars per assay, although some commercially available kits can cost about $20 per sample.

Current research interests in this area at the National Water Research Institute (NWRI), include the development of radioimmunoassay (RIA) techniques for PCDDs, and the determination of their performance characteristics with a variety of environmental matrices. Eventually it is hoped to have a battery of screening tests for the detection of a range of environmental contaminants.

The s-triazine herbicides, in particular atrazine, and some of their degradation products, are suitable candidates for detection using IAs. An atrazine IA would facilitate the monitoring of surface and groundwaters for the presence of these herbicides. Because environmental samples usually require less, if any, cleanup for IAs than with conventional analytical methods, the proposed screening technique could expedite the inclusion of atrazine in surveillance or monitoring programs. The atrazine IA is suggested for use as a pre-screening technique that would complement, not replace, conventional analytical methods. Samples that test positive using IA would have to be confirmed using conventional techniques. However, because the atrazine IA would reduce the number of samples requiring more time consuming and expensive conventional analysis, it could contribute to the cost effective determination of the presence, levels, trends and environmental effects of atrazine in freshwater bodies.

The original project objectives were as follows:

- Obtain anti-atrazine antibodies; it was hoped to involve a transfer of technology between the manufacturer and the Canadian Centre for Inland Waters (CCIW). Should antibodies be unavailable, it was planned to generate polyclonal antibodies in New Zealand White rabbits.

- Label an atrazine derivative with I-125, or a suitable enzyme marker, and verify the ability of the previously raised, or acquired, antibodies to bind it.

- Develop and evaluate an IA procedure.

Contact was made with the leading researchers in this area. Antibodies were unavailable from any

of these sources. At this stage two commercial sources of anti-atrazine antibodies emerged. The companies involved are ImmunoSystems and Westinghouse, both located in the USA. Consultations with researchers at both companies indicated that rather than selling anti-atrazine antibodies, they were both marketing IA kits. The kits from each company retail at approximately $225 (Can) for a 10 sample kit. Consequently, it was decided to evaluate the commercially available kits to determine their suitability.

Methodology. The **ImmunoSystems assay** is tube based. Anti-atrazine antibodies are bound to the walls of plastic tubes. Both an analyte-enzyme (horse radish peroxidase) conjugate and the sample, which may contain atrazine, are added to the tube. During a 5-minute incubation period, atrazine and atrazine-enzyme compete for antibody binding sites. The sample is then rinsed from the tube. Next, substrate and chromogen are added to the tube. The antibody bound enzyme converts the substrate to a compound which in turn causes the chromogen to turn blue. The lighter the colour, the more atrazine is present in the sample. The tubes may be read visually, or a 500 µL portion can be transferred to a micro-well and measured spectrophotometrically.

The **Westinghouse assay** is micro-titre plate based (96 well mini-reaction platforms). Protein linked atrazine is bound to the walls of the micro-wells. Antiserum and sample are added to the wells and incubated; during this incubation period, the antibodies bind to the immobilized atrazine; binding is inhibited by any free atrazine in the sample. Free antibodies and sample are then washed from the wells. In the next step, anti-rabbit gamma globulin antibodies tagged with alkaline phosphatase are added to the wells, and the plates are again incubated. After rinsing free enzyme from the wells, substrate is added to the wells; substrate conversion is determined spectrophotometrically using a micro-plate reader.

A recently announced micro-titre plate version of the **ImmunoSystems** assay was also evaluated in pre-market form for the manufacturer.

Results and Discussion. Results obtained using the **Immunosystems tube assay** are promising. Using laboratory standards it was possible to detect 0.1 ppb of atrazine using a 10-minute test, without sample extraction or cleanup. Some problems concerning assay variability were investigated and resolved. The assay was interfaced with a conventional extraction and cleanup procedure which lowered the detection limit to the picograms/L level.

Further evaluation of the kits is being undertaken in four stages:

1. Assay performance using laboratory standards
2. Assay performance using spiked lake and river water
3. Assay performance using spiked extracts of lake and river water
4. Assay performance using a variety (about 70) of triazine contaminated environmental water samples; these samples are also being analyzed using the conventional method. Inland Waters Directorate (IWD) Ontario region and the National Water Quality Lab (NWQL) are participating in this evaluation.

With the **micro-plate version of the ImmunoSystems Assay**, a detection limit of 12.5 ppt was achieved without difficulty. An excellent dose response was achieved between 12.5 and 50 ppt. A 15 sample set of environmental water samples was also analyzed. The samples were from a variety of locations and contained various levels of atrazine. Good agreement was observed between the IA and GC results (correlation coefficient of 0.94).

Further tests are planned with this system. The results of this study were provided to ImmunoSystems Inc., to assist them with product development.

A **rapid sample preparation technique** was developed for use in conjunction with the IA screening technique. It is planned to complete validation of this method, and to interface it with the screening assay as an ancillary project. Manpower is the limiting factor at the moment. A contract technician was employed during the latter

part of 1988 to assist in the laboratory investigations.

The preliminary results of this work were presented at the BIOQUAL '88 workshop and at the NWRI (DOE)/Laboratory Services Branch (MOE) METHOD DEVELOPMENT SEMINAR '89.

For more information, contact:

J. Sherry
National Water Research Institute
867 Lakeshore Rd.
Burlington, Ontario
L7R 4A6

(416) 336-4813

4. USE OF ACETYLCHOLINESTERASE TO DETECT THE EFFECTS OF SUBLETHAL CONCENTRATIONS OF ORGANOPHOSPHATE INSECTICIDES ON AQUATIC INVERTEBRATES - (Kristin E. Day and Ian Scott, N.W.R.I., Burlington, Ontario)

Introduction. Organophosphate insecticides can contaminate surface waters through intentional application during control of biting insects, or unintentionally by atmospheric fallout, soil erosion, industrial effluent, sewage, or spills. Aquatic invertebrates living in such surface waters can therefore be exposed to insecticide levels which range from acutely lethal to sublethal. Traditionally, insecticide residues occurring in water near areas of application have been difficult to correlate with sublethal effects on invertebrates and there is a need for diagnostic tests that can correlate toxicant-induced responses with the health of aquatic organisms.

Organophosphate insecticides act as nerve poisons by blocking synaptic transmission in the cholinergic portions of the nervous system. The disruption of nerve impulse transfers is caused by excessive accumulation of the neurotransmitter, acetylcholine (ACH) which is normally broken down by the enzyme acetylcholinesterase (ACHE). Organophosphates bind to the active site of ACHE and prevent the breakdown of ACH. Inhibition of ACHE activity in combination with chemical residues in fish and birds have been used as a tool in diagnosing organophosphate poisoning but few studies have looked at the effects of these insecticides on ACHE levels in aquatic invertebrates.

The objective of this research is to develop methodology to measure levels of ACHE in aquatic invertebrates exposed to low concentrations of organophosphate insecticides and to determine if any observed changes are a good biochemical indicator of sublethal toxicity.

Methodology. Several types of aquatic invertebrates obtained from laboratory cultures or local rivers and streams were used in this study. They ranged in size from the cladoceran, *Daphnia magna* to stoneflies and included the amphipod, *Hyalella azteca*, isopods, mayflies and caddisflies. Several *in vitro* and *in vivo* exposure tests (24-h to 72-h) were performed with the organophosphate insecticides, azinophos-methyl, chloropyrifos and fenitrothion. Levels of ACHE were measured using a microassay technique based on modifications of the Ellman methodology.

Results and Discussion. There were no significant differences in the levels of ACHE in animals or tissue homogenates exposed to sublethal concentrations of the three organophosphate insecticides at any of the concentrations tested. These results suggest that the use of ACHE levels in aquatic invertebrates exposed to low concentrations of organophosphate insecticides is not a good diagnostic tool for detecting sublethal toxicity.

For more information, contact:

Dr. Kristin Day
National Water Research Institute
P.O. Box 5050
867 Lakeshore Rd.
Burlington, Ontario
L7R 4A6

(416) 336-4659

5. CHEMICAL AND PHOTOCHEMICAL ISOMERIZATION OF DELTAMETHRIN - (R.J. Maguire)

Introduction. The powerful pyrethroid insecticide deltamethrin is registered in Canada for use on a variety of crops. Contamination of streams and ponds near sprayed fields is undesirable because of the high toxicity of deltamethrin to aquatic organisms. For this reason buffer zones of 15 and 100 m are commonly used between sprayed areas and water when deltamethrin is sprayed from the ground or air, respectively. Despite these precautions some deltamethrin may drift to water, and it is necessary to characterize the aquatic persistence and fate of deltamethrin. Earlier studies have not distinguished between isomers of deltamethrin of differing activities. There are eight possible stereoisomers (i.e., optical isomers) of deltamethrin, and only the parent compound, designated 1-deltamethrin, and, to a lesser extent, 3-deltamethrin are active, at least against mammals and insects. A chiral analysis conducted previously may have overestimated the concentrations of active deltamethrin stereoisomers. A complete description of the environmental dynamics of deltamethrin therefore requires the determination of all eight stereoisomers.

The objective of this work was to use a chiral method of analysis (i.e., one that is capable of distinguishing between stereoisomers) for deltamethrin to determine which isomers are produced chemically and photochemically in natural water and thus obtain a more accurate estimate of the persistence of active isomers.

Methodology. Analytical standards of the parent 1-deltamethrin and the other seven stereoisomers were obtained from the manufacturer. Analyses were carried out by high performance liquid chromatography with a diode array spectrophotometric detector and a chiral (R)-N-3,5-dinitrobenzoylphenylglycine column. Triplicate experiments were carried out on the isomerization of 1-deltamethrin in natural water in the dark as well as in sunlight. Additional experiments were carried out in hexane, on thin films on glass and on potato leaves. Appropriate controls were employed in all cases.

Results and Discussion. In this work, chiral (optically active) high performance liquid chromatographic analyses have shown that 1-deltamethrin in natural water in the dark is subject to cis/trans isomerization yielding 2'-deltamethrin, which is inactive against mice and insects, and probably aquatic organisms. Sunlight irradiation of 1-deltamethrin as a thin film on glass, on potato leaves, in natural water and hexane produce 2'-deltamethrin as well as the less active 3-deltamethrin and the inactive 4'-deltamethrin. The persistence of active deltamethrin residues in aquatic ecosystems, therefore, is probably lower than previously determined by achiral analyses.

Although the isomerization of 1-deltamethrin may be viewed as at least a partial detoxification mechanism in mammals and insects, further research is required on the toxicity of deltamethrin isomers to aquatic organisms in order to make the same statement for aquatic ecosystems.

For more information, contact:

Dr. R.J. Maguire
National Water Research Institute
P.O. Box 5050
867 Lakeshore Road
Burlington, Ontario
L7R 4A6

(416) 336-4776

6. 1,2-DICHLOROPROPANE AND 1,3-DICHLOROPROPENE METHODS DEVELOPMENT

- (M.A. Forbes, National Water Quality Laboratory, Burlington, Ontario)

Introduction. Plant parasitic nematodes, often microscopic in size, proliferate in warm, porous, sandy soils typical of many agricultural areas. They are considered a major agricultural pest since large infestations can destroy developing root systems, affecting plant vigour and resulting in reduced crop yields that can exceed 50% if left untreated.

Both 1,2-dichloropropane and 1,3-dichloropropene are water soluble, highly volatile liquids widely used as chemical intermediates in industry, in paint removers, degreasing agents and dry cleaning fluids and as soil fumigants to control nematodes.

Although 1,2-dichloropropane and 1,3-dichloropropene were first introduced by Dow chemical in 1943, it was not until 1977 that use of these chemicals increased dramatically as a pesticide (particularly in the U.S.) because of the ban imposed on DBCP (1,2-dibromo-3-chloropropane) which up to that time had been in major use.

The latest survey of pesticide use in Ontario identified 1,2-dichloropropane and 1,3-dichloropropene as second only to atrazine with over 1.3×10^6 kg applied in 1983 in the tobacco growing region of Ontario.

The major biologically active ingredient in soil fumigants is 1,3-dichloropropene, while 1,2-dichloropropane is a manufacturing by-product. Although little information is available on the acute and chronic toxicity of 1,2-dichloropropane alone since most references cite mixtures of 1,2-dichloropropane and 1,3-dichloropropene, both compounds are moderately toxic to mammals and aquatic life. Toxicity studies have shown that 1,2-dichloropropane is less toxic than 1,3-dichloropropene and is a less effective nematocide.

The fate of the two compounds after application is, therefore, of primary concern. The most important mechanisms of environmental dispersion are vaporization from soil and water and diffusion through soil where contamination of groundwater results. Although 1,2-dichloropropane has been shown to be stable in some soils for years, there is evidence that biodegradation can take place depending on chemical concentration and presence and population of microbial species. 1,3-dichloropropene, on the other hand, can be hydrolysed in soil to produce 3-chloroallyl alcohol which is not as mobile, perhaps due to its ability to bind to certain soils.

Due to the continued and intensive use of 1,2-dichloropropane and 1,3-dichloropropene, the goal of this study was to develop methods that are both sensitive and reliable for routine analysis of these compounds.

Methodology. 1,2-dichloropropane and cis- and trans-1,3-dichloropropene were spiked along with isotopically labelled benzene as internal standard into previously purged water, sparged from solution onto Tenax using a purge and trap apparatus, desorbed onto a liquid nitrogen trap, vaporized, separated by gas chromatography and analyzed by an ion trap detector.

Results and Discussion. Chromatographic separation of the volatiles was accomplished easily with a 30 m DB-5 fused silica capillary column. The temperature program started at 35°C due to the high volatility of the compounds. A final temperature of 250°C ensured that all volatile components would be driven off. Blanks run with the spikes showed no evidence of carryover.

Data were collected for the four peaks in full scan mode. Integrated peak areas for ions 84, 63 and 75 were used for quantitation of benzene-D6, 1,2-dichloropropane and cis- and trans-1,3-dichloropropene, respectively.

The collection of data in full scan mode allowed review of the spectra for each compound and

facilitated the addition to a spectral library to aid in identification in complex mixtures.

A series of spikes at 1.0 and 2.0 µg/L were run to establish recovery and to determine detection limits. The detection limits were 0.17, 0.13 and 0.11 µg/L for 1,2-dichloropropane, cis- and trans-1,3-dichloropropene, respectively.

This simple and reproducible method has already been used in the analysis of groundwater collected from areas in Ontario where these fumigants have been applied.

For more information, contact:

M.A. Forbes
National Water Quality Laboratory
867 Lakeshore Road
P.O. Box 5050
Burlington, Ontario
L7R 4A6

(416) 336-4577

7. PESTICIDES IN SOUTHERN ONTARIO RAINWATER - (John Struger, C.H. Chan, and M. Wong)

Introduction. It has been postulated that rainfall can transport pesticides from their places of application into aquatic systems. Only two previous studies were found documenting the presence of in-use agricultural pesticide residues in rainwater. To further investigate this hypothesis, the major herbicides applied to row crops (i.e., corn and soybeans) in southern Ontario were monitored from a single precipitation monitoring station on Pelee Island. The pesticides looked for included the triazine (atrazine), the acetanilide (metolachlor) and the chlorophenoxy-acid (2,4-D and MCPA) herbicides.

Methodology. Biweekly monitoring of wet precipitation at Pelee Island was undertaken between June and October 1988. In 1988, six GC-MS investigative screening scans were done on samples collected from Pelee Island, Sibley Provincial Park (Thunder Bay) and South Beymouth (Manitoulin Island).

Results and Discussion. Fifteen different herbicides were looked for in the precipitation, none were detected over the four months of the study. Results from the GC-MS investigative screening scans yielded no positive identification for any of the neutral or phenoxy acid herbicides. Although neutral herbicides were not detected in any samples a number of hydrocarbons were detected including alpha-BHC and several PAHs. In 1989, the sampling site was moved to St. Anne's Island near Wallaceburg, Ontario to be more representative of a corn-soybean producing area.

For more information, contact:

John Struger
Water Quality Branch
Ontario Region
Canada Centre for Inland Waters
Box 5050
Burlington, Ontario
L7R 4A6

(416) 336-4966

8. ATRAZINE AND METOLACHLOR IN AGRICULTURAL RUNOFF - (John Struger and John Fischer)

Introduction. Contamination of surface runoff with pesticide residues is a problem in many areas of agricultural activity in North America. Large amounts of atrazine and metolachlor are used in the production of corn and soybeans in southern Ontario especially in the Thames River watershed. The Water Quality Branch - Ontario Region in cooperation with the Upper Thames River Conservation Authority (UTRCA), undertook a study to determine the potential for harm of neutral and phenoxy acid herbicides in surface water from a small paired watershed in Kintore Creek near Thamesford, Ontario.

Methodology. The stream was sampled at regular two week intervals; and during periods of rain when the stream discharge was increasing.

Water samples were collected by an ISCO automatic water sampler (Model #2700) fitted with glass sample bottles. Events were monitored for @ 12 h with 8 sampling intervals. The water samples were analyzed for seven neutral herbicides and eight phenoxy acid herbicides. Other information was also collected, including other chemical constituents and water flow. Sediment samples were collected and analyzed for neutral herbicides and organochlorine pesticides.

A pesticide usage questionnaire was completed by each landowner in the watershed which documented field crops and the types of pesticides used in the watershed.

A fisheries assessment was also carried out on both branches of Kintore Creek by the Ontario Ministry of Natural Resources, UTRCA and WQB.

Activities were also coordinated with two projects by K. Day of the River Research Branch of the National Water Research Institute (NWRI) in Burlington which investigated whether conventional vs. conservation tillage had any impact on the productivity of periphyton and stream invertebrates.

Results and Discussion. Due to the unusually dry weather experienced during the spring and summer of 1988 the data were not as conclusive as had been expected. Only two significant rain events occurred in the summer. During the first (July 22), concentrations of up to 32 µg/L of metolachlor and 11 µg/L of atrazine were found in the creek. All samples collected in the east branch (conventional tillage) contained both atrazine and metolachlor with atrazine being consistently higher, while only 4 of 8 samples in the West branch (conservation tillage) contained detectable levels of herbicides. Metolachlor was present in higher concentrations than atrazine and both herbicides were found in higher concentrations in the west branch than in the east branch.

Biweekly water samples collected in both branches confirmed significant carry-over of atrazine from the previous growing season suggesting that atrazine does not degrade completely from one year to the next. Grab samples from a catch-basin associated with a tile drain indicated sub-surface movement and/or groundwater flow of atrazine during low precipitation periods.

Twenty-two different pesticides (primarily herbicides) were used in the watersheds. Application rates, field acreages and crop information were also collected.

This project was continued in 1989-90. This information is needed to identify pesticides of concern from a water quality perspective and to provide information on the possible effects of agricultural herbicides to Agriculture Canada in their re-evaluation process.

For more information, contact:

John Struger
Water Quality Branch - Ontario Region
Canada Centre for Inland Waters
Box 5050
Burlington, Ontario
L7R 4A6

(416) 336-4966

9. THE BIOLOGICAL IMPACT OF AGRICULTURAL RUNOFF FROM CONVENTIONAL VERSUS CONSERVATION TILLAGE: EFFECTS ON PRIMARY AND SECONDARY PRODUCTIVITY - (Kristin E. Day and Rosanna Sallenave, N.W.R.I., Burlington, Ontario)

Introduction. Agricultural runoff is one of the main contributing factors to non-point sources of contamination in aquatic ecosystems. In recent years, reduced tillage and no-till practices in Canadian and U.S. agriculture have been on the increase (i.e., any method that leaves at least 20 to 30% of the soil surface protected by crop residue). The advantages of conservation tillage are many and include control of soil erosion by reduction of surface runoff and reduced nutrient loadings to watersheds. However, it has also been suggested that conservation tillage may require increased usage of pesticides, particularly herbicides, for the chemical control of weeds and insects, and this may result in increased concentrations of pesticides in watershed runoff.

There have been few studies to determine the concentrations of pesticides in runoff water from conservation versus conventional tillage under realistic field conditions. In addition, little information is available on the ecotoxicological effects of such runoff in aquatic ecosystems adjacent to agricultural land and there is a need for techniques to monitor these effects in the field.

Therefore, the objective of this research is to monitor the concentrations of pesticides (atrazine and metolachlor) and nutrients in agricultural runoff from land subjected to conservation versus conventional tillage practices in southwestern Ontario and to compare the effects of this runoff on the growth and productivity of attached algae (periphyton) and benthic invertebrates found in two adjacent subwatersheds.

Methodology. The collection of data in the two subwatersheds consisted of the following sampling regimes:

a) Artificial substrates for the attachment of periphyton in the form of unglazed ceramic tiles were installed in the two subwatersheds during the 1988 and the 1989 growing seasons. Growth of periphyton on the tiles was monitored by periodic sampling for ash-free dry weight, chlorophyll *a*, and taxonomic composition by scraping a portion of the algal biomass from four replicated tiles.

b) Annual secondary productivity of the benthic invertebrate communities (*Hydropsyche* spp. and *Chemopsyche* spp.) was estimated from quantitative field samples (replicated Surber samples) collected at monthly intervals from May 1988 to July 1989 using the size-frequency method.

c) The collection of water samples for the determination of pesticide residues and nutrient analysis (total phosphorus, soluble reactive phosphorus, nitrites-nitrates, and suspended sediment) was conducted by Water Quality Branch, Ontario Region, Burlington and the Upper Thames River Conservation Authority. Sampling of water during storm runoff events was achieved through the installation of ISOC automated water samplers. The analysis of water for pesticide residues was conducted at the National Water Quality Laboratory, Burlington, Ontario.

Preliminary Results and Discussion. There were very few runoff events during the 1988 growing season due to the severe drought that southern Ontario experienced during the spring-summer. Data for the 1989 growing season are not yet available. However, preliminary results from bimonthly water samples suggest that concentrations of atrazine were slightly higher in the subwatershed practicing conventional tillage even though more pesticides and higher concentrations of pesticides were used in the conservation tillage area. Metolachlor was not detected in the majority of samples collected throughout the year.

Growth of periphyton on unglazed ceramic tiles and estimates of the standing stock of invertebrates in the two subwatersheds suggests that productivity of both plant and animal biota is higher in the subwatershed practicing conservation tillage. This may be a reflection of reduced input of agricultural chemicals. However, nutrients (phosphorus and nitrite-nitrates) were found at higher concentrations in the conservation tillage watershed and may be contributing to the increased growth of algae and the associated fauna. A full report on the results from this study will be available during 1991.

For more information, contact:

Dr. Kristin Day
National Water Research Institute
Burlington, Ontario
L7R 4A6

(416) 336-4659

10. NEMATICIDES IN SURFACE AND GROUNDWATERS OF BIG CREEK WATERSHED - (John Merriman and John Struger)

Introduction. Nematicides are designed to be mobile in the soil/water environment to protect the root zone, where pest problems occur. Most severe pest problems are encountered in sandy, porous soils with low water holding capacity, which increases the likelihood of leaching to ground and surface waters. Big Creek is located in Ontario's major tobacco growing area which is characterized by sandy soils with low water holding capacity. According to the latest survey of pesticide use in Ontario, 1,2-dichloropropane and 1,3-dichloropropene ranked second to atrazine in total quantities used, with over 1.3 million kg applied in 1983. The major biologically active ingredient in soil fumigants is 1,3-dichloropropene, while 1,2-dichloropropane is a manufacturing by-product.

In 1989, the Water Quality Branch, Ontario Region undertook a study to determine the presence/absence of 1,2-dichloropropane and 1,3-dichloropropene in the Big Creek watershed. Due to the highly volatile nature of these compounds, it was not known whether they would be present in surface or groundwaters. The primary objective of the study is to determine environmental concentrations and spatial distribution of the compounds and to relate this to other land use information so that an ongoing monitoring plan for the watershed can be developed. Data on environmental concentrations that may be useful to Agriculture Canada in their re-evaluation of registered pesticide products will also be provided.

Methodology. Samples were obtained at seven locations; four surface water and three groundwater sites. Water was collected in 40-mL glass bottles with Teflon septa and analyzed using a purge and trap technique. Weekly sampling began in late April before application of 1,2-dichloropropane and 1,3-dichloropropene and increased to twice weekly during the application period (second and third weeks of May). This continued until the third week in May when weekly sampling was re-commenced until mid-June. This was followed by one collection in July. Sampling was carried out over a variety of climatic conditions, including dry periods and during and after rain events. One duplicate sample was collected during each sampling run.

Results and Discussion. Over the sampling period, 1,2-dichloropropane was not detected in any samples above the detection limit of 0.16 µg/L. This is not surprising, because it is a manufacturing by-product of 1,3-dichloropropene and is present in very low concentrations in the formulation.

The active ingredient, 1,3-dichloropropene which includes both cis- and trans-isomers, was present at four of the seven sites sampled. This compound was found only at the surface water stations and was not found above the detection level at any of the groundwater sites. Concentrations ranged from 0.15 to 4.12 µg/L for 1,3-dichloropropene (total cis and trans). The detection limits are 0.12 and 0.14 µg/L for cis- and trans-1,3-dichloropropene, respectively.

All detectable concentrations of 1,3-dichloropropene occurred either during or very shortly after application of the soil fumigants. There were no detectable levels found after the May 18, 1989 survey, which suggests that it is not very persistant in riverine situations.

Concentrations of 1,3-dichloropropene tended to be higher at the upstream sites which were located in smaller tributaries of Big Creek and adjacent to tobacco crops, compared to the downstream sites which were located outside the tobacco growing area, but still influenced by it.

The results of this pilot study show that soil fumigants can be detected in river water if sampled in a timely manner. The compounds of interest do not remain in the aquatic environment for very long periods. Further work is required to establish a monitoring program for the watershed, with the possibility of looking for other active ingredients in soil fumigants.

For more information, contact:

John Merriman
Water Quality Branch - Ontario Region
Canada Centre for Inland Waters
P.O. Box 5050
Burlington, Ontario
L7R 4A6

(416) 336-4962

11. BIOACCUMULATION AND BIODEGRADATION OF TRIBUTYLTIN - (Y.K. Chau (NWRI), P.T.S. Wong (GLLFAS*), and D. Liu (NWRI))

Introduction. Tributyltin is used extensively in antifouling paints for ships and docks, as lumber preservative, and as slimicide in cooling towers. Although its use has been regulated in Canada, recent findings of butyltin species in salmon reared in sea pens in British Columbia, and in fish in Ontario harbours (Whitby and Oshawa) have raised much concern by Fisheries and Oceans Canada and Environment Canada. The occurrence and toxic effects of tributyltin in oysters have been reported in France and in Canada.

The objective of this study was to study the aquatic pathways of tributyltin by determining its bioaccumulation and biodegradation by caged mussels in contaminated harbour areas, and in the laboratory with contaminated sediments.

Methodology. Caged mussels (*Elliptio complanata*) experiments were carried out in Whitby and Oshawa Harbours. Parallel experiments were carried out in the laboratory by exposing mussels to contaminated sediments. Biodegradation studies were carried out in the laboratory with cyclone fermentors under aerobic and anaerobic conditions, and at various nutrient levels. A GC-AAS technique was used for speciation of butyltin compounds in sediment and in mussels.

Results and Discussion. Biodegradation investigations were completed and the results have been published.

Under laboratory conditions, accumulation of tributyltin by mussels reached a maximum of 24 $ng \cdot g^{-1}$ from Whitby Harbour sediment which contained 66 to 110 $ng \cdot g^{-1}$ of tributyltin. Concentration of tributyltin in Oshawa sediment was low (32 to 38 $ng \cdot g^{-1}$), accumulation by mussels was not significant. Accumulation rate and level of accumulation in mussels are positively related to the concentration of tributyltin in sediment.

Accumulation of tributyltin by mussels was higher in both locations in Whitby Harbour than in Oshawa Harbour. In the inner harbour locations, the accumulation rates were 2.1 and 0.7 $ng \cdot day^{-1}$ respectively for Whitby and Oshawa over a 140-day exposure period. Concentration factors of mussels over water ranged from 4.8×10^{3} to 18.5×10^{3}. Concentration factors over sediment were 0.1 to 10.0 for Oshawa harbour, and 2.5 to 18.1 for Whitby Harbour.

This investigation also indicated that tributyltin in sediment of contaminated harbours is available to mussels.

Publications. Tian, Shizhong, Chau, Y.K., and D. Liu, "Biodegradation of Bis(tri-n-butyltin) Oxide," Appl. Organomet. Chem., 3: 249-255 (1989).

Chau, Y.K., Wong, P.T.S., Bengert, G.B., and J. Yaromich, "Bioaccumulation of Butyltin Compounds by Mussels in Harbours", Submitted to Chemical Speciation and Bioavailability (1989).

* Great Lakes Laboratory for Fish and Aquatic Sciences

For more information, contact:

Dr. Y.K. Chau
National Water Research Institute
P.O. Box 5050
867 Lakeshore Road
Burlington, Ontario
L7R 4A6

(416) 336-4814

12. BIODEGRADATION OF CONTAMINANT IN FLUVIAL SYSTEMS - (D. Liu, Y.K. Chau and B.J. Dutka)

Introduction. Recent advancement in ecotoxicology has established that the fate and behaviour of a contaminant in the environment are largely determined by its degradability and toxicity. Consequently, the possible impact of a chemical on the environment can be approximated from the analysis of its biodegradability and toxicity data alone.

The objective of this study was to systematically investigate the biodegradation/toxicity of priority contaminants/pesticides in a laboratory model fluvial system, with the emphasis on biodegradation mechanisms/processes, biotransformation products, and factors affecting the contaminant's bioactivity and persistence.

Methodology. Two rapid, simple and sensitive bioassay procedures were developed for determining the chemical toxicity of both water-soluble and -insoluble compounds. The biodegradation mechanism of pentachlorophenol was evaluated in the cyclone fermentor, and the biodegradation of tributyltin was performed using a 40-L model river system. Degradation products were identified by GC and GCAA techniques.

Results and Discussion. Five pesticides (carbaryl, fenitrothion, toxaphene, 2,4-D, and 2,4,5-T), 5 chlorophenols, and 4 organotin compounds, among others were used to develop the two bioassay techniques[1,2]. Both procedures can be used for toxicity screening and structure-activity studies. On the biodegradation research, our pentachlorophenol study indicated that first-order kinetics alone can not be used to predict accurately the fate of a persistent chemical in the environment. Factors that may influence a chemical's biodegradability in the natural environment must be considered in the design of a laboratory biodegradation experiment[3]. The organotin compound bis(tri-n-butyltin) oxide was found to be biodegradable under both aerobic and anaerobic conditions with half-lives of five and three days, respectively. The degradation follows a sequential dealkylation process[4].

References

1. Liu, D., Y.K. Chau, and B.J. Dutka, "Rapid Toxicity Assessment of Water-soluble and Water-insoluble Chemicals Using a Modified Agar Plate Method," Water Research, 23:333-339 (1989).

2. Liu, D., "A Rapid and Simple Biochemical Test for Direct Determination of Chemical Toxicity," Toxic. Assess., 4:399-404 (1989).

3. Liu, D. "Biodegradation of Pentachlorophenol and its Commercial Formulation," Toxic. Assess., 4:115-127 (1989).

4. Tian, S., Y.K. Chau, and D. Liu, "Biodegradation of Bis(tri-*n*-butyltin) Oxide," Appl. Organometal., 3:249-255 (1989).

For more information, contact:

Dickson Liu
National Water Research Institute
867 Lakeshore Road
Burlington, Ontario
L7R 4A6

(416) 336-4576

13. ENVIRONMENTAL DYNAMICS OF BENZOTHIAZOLE-BASED PESTICIDES - (Brian G. Brownlee (Rivers Research Branch, National Water Research Institute), John H. Carey (Lakes Research Branch, National Water Research Institute)

Introduction. The fungicide, 2-(thiocyanomethylthio) benzothiazole (TCMTB), is one of the possible replacements for chlorophenols used as wood protecting and preserving agents. The British Columbia government has recently announced new regulations which will likely see the phasing out of chlorophenol use in the lumber industry in that province. However, very little information on TCMTB and its potential degradation products in aquatic environments is available. This study was undertaken to provide this type of information.

Preliminary work on the hydrolysis, photolysis, water solubility, and partitioning (octanol-water and sediment-water) of TCMTB was completed in 1988/89.

Methodology. TCMTB is not sufficiently stable to be analyzed by gas-liquid chromatography but can be analyzed by high performance liquid chromatography (HPLC). All of our work has been done with a 25 cm reverse phase column (C_{18}), acetonitrile-water (50:50, v/v) as the mobile phase, and detection at 280 nm.

Hydrolysis experiments were carried out in buffered solutions and TCMTB disappearance followed by direct analysis by HPLC.

Photolysis experiments were carried out in buffered solutions placed in direct sunlight. TCMTB disappearance and product analysis were done by direct analysis by HPLC.

Water solubility was determined by equilibrating solid TCMTB with distilled water and determining the concentration by HPLC.

The octanol-water partition coefficient (K_{ow}) was determined by shaking a solution of TCMTB in water-saturated 1-octanol with 1-octanol-saturated water and determining the concentration in both phases.

Sediment-water partitioning was examined by shaking an aqueous solution of TCMTB with a sample of suspended particulate material from a southern Ontario stream. The particulate material was collected, extracted and analyzed for TCMTB.

Results and Discussion. **Hydrolysis.** In 0.005 M Tris buffer at 24°C and pH 8.0, the pseudo first-order hydrolysis rate constant was 0.004 h^{-1} (half-life of ca. 180 h). However, the Tris buffer appeared to accelerate the hydrolysis rate, and hydrolysis in natural waters is probably slower than indicated by these experiments. TCMTB would be moderately persistent under natural conditions (5 to 25°C, pH 7 to 8).

2-Mercaptobenzothiazole (MBT) was produced in quantitative yield from the hydrolysis of TCMTB.

Photolysis. TCMTB underwent rapid photodegradation in direct sunlight at pH 6 in phosphate buffer. Two reaction products were detected by HPLC. MBT was produced in about 50% yield and benzothiazole in about 5% yield.

Water Solubility. The water solubility of TCMTB in pure water was 40 mg/L at 24°C and 16 mg/L at 5°C. Solubility in a natural water (dissolved organic carbon = 8 mg/L) was the same at both temperatures.

Octanol-water Partitioning. The measured value of $\log_{10} K_{ow}$ for TCMTB in pure water was 3.12 and for a natural water it was 3.15 (both at 24°C).

Sediment-water Partitioning. In this experiment, no TCMTB could be detected in the sediment. However, there was some evidence that the TCMTB was hydrolyzed to MBT due to the very high sediment concentrations used (1 g/L).

Summary. From the water solubility and octanol-water partition coefficient, TCMTB is not likely to bioaccumulate greatly in organisms nor to bind strongly to sediments. At pH 7-8 in natural waters, photolysis may be a more important degradative pathway than hydrolysis. This will require further investigation.

Another research need is for development of sensitive analytical methods for TCMTB in water, sediment and fish so that releases into receiving waters can be monitored. The urgency of this need was underscored by a recent spill of TCMTB into the Fraser River.

For more information, contact:

Brian G. Brownlee
Rivers Research Branch
National Water Research Institute
867 Lakeshore Road
Burlington, Ontario
L7R 4A6

(416) 336-4706

14. ANNUAL MONITORING OF CONTAMINANT LEVELS AND BIOEFFECTS IN FISH-EATING BIRDS ON THE GREAT LAKES: I. CONTAMINANT LEVELS IN HERRING GULL EGGS - (Dr. D.V. Chip Weseloh)

Introduction. In the early 1970s it was recognized that there was a need for a long-term, ongoing project to monitor the levels of contaminants in wildlife on the Great Lakes. A project was initiated in 1974 to analyze gull eggs annually for a host of organochlorine compounds. This project has been maintained since that time and is now in its 15th year. The data generated have been invaluable in tracing the changes in contaminant levels in wildlife and in corroborating similar studies at other levels of the food chain.

The objectives of this study were to determine and report on:

1) the long-term temporal and spatial trends of selected contaminants in the eggs of Herring Gulls from throughout the Great Lakes; and

2) to submit for publication a paper updating contaminant levels in Herring Gulls from the Annual Monitor Colonies.

Methodology. Fresh Herring Gull eggs are collected and analyzed each year from the same 13 colonies from throughout the Great Lakes and connecting channels.

Results and Discussion. Levels of the five major contaminants (DDE, dieldrin, mirex, HCB and PCBs) in Herring Gull eggs collected in 1988 showed a small but general increase. Eighty-eight percent of these cases increased or showed no change from 1987. This is not necessarily indicative of an upward trend but rather may show the yearly fluctuation which is present in Herring Gull eggs (e.g., in 1987 most compounds decreased). Values in 1988 were still well below levels recorded at the beginning of the decade.

On a geographical basis, the lake or connecting channel with the highest levels of each compound were as follows: DDE and dieldrin (Lake Michigan), mirex (Lake Ontario), HCB and PCBs (Detroit River). This is much the same as the pattern over the last several years.

For further information, contact:

Dr. Chip Weseloh
Canadian Wildlife Service
Box 5050
Canada Centre for Inland Waters
Burlington, Ontario
L7R 4A6

(416) 968-7251

15. ANNUAL MONITORING OF CONTAMINANT LEVELS AND BIOEFFECTS IN FISH-EATING BIRDS ON THE GREAT LAKES. II CONGENITAL ANOMALIES IN EMBRYONIC AND POST-HATCH DOUBLE-CRESTED CORMORANTS (DCCs) -

(Dr. Jim Ludwig, Ecological Research Services*, and Dr. D.V. Chip Weseloh, Canadian Wildlife Service)

Introduction. Birth defects (congenital anomalies) are known to occur in some wildlife species that inhabit areas of high chemical contamination. One of the species which appears to be most susceptible to these birth defects is the Double-crested Cormorant. The rate of occurrence of one type of defect (crossed bill) in young hatched cormorants is over 50 per 10,000 in Green Bay, Lake Michigan; in other areas rates are in the range of 6 - 10 per 10,000.

The objectives of this study were:

- to determine the fertility and hatchability of eggs of the cormorants as well as the frequency, stage of embryonic development and true rate of occurrence of developmental abnormalities in DCCs on the Great Lakes; and

- to measure the rate of occurrence of developmental defects early and late in the incubation period by physical inspection and compare this to that found in embryos which have died as detected by the Embryonic Viability Detector.

Methodology. Cormorant eggs, both dead and alive, were opened at various stages of incubation and post-incubation on a test colony in Lake Ontario and on a control colony in Lake Winnipegosis. Age of the embryo, development of congenital anomalies and size of the breeding population were assessed.

Results and Discussion. More than 80% of the eggs at both sites showed normal development. However, the rate of infertility and occurrence of abnormal embryos was twice as great among cormorant eggs from Lake Ontario as compared to Lake Winnipegosis. Detection of abnormal embryos was much greater in late, rather than early incubation. The rates of occurrence of bill deformities in hatched cormorants on the test and control colonies were 10.4 and 4.8 per 10 000, respectively. For the Great Lakes and Lake Winnipegosis as separate water bodies, the rates for bill deformities were 4.9 and 10.4 per 10,000, respectively. The higher rate at Lake Winnipegosis is, at this point, an unexplained anomaly.

In Lakes Ontario and Erie and the Canadian portions of Huron and Superior we recorded 10,653 cormorant nests. This compares to just over 8,000 in the same area in 1987 and represents a growth of approximately 29%. The dramatic increase in the Great Lakes cormorant population that started in the late 1970s in still continuing.

* The Academy Centre
512 N. Lincoln
Bay City, MI
48708, U.S.A.

For further information, contact:

Dr. D.V. Chip Weseloh
Canadian Wildlife Service
Box 5050
Canada Centre for Inland Waters
Burlington, Ontario
L7R 4A6

(416) 968-7251

16. ANNUAL MONITORING OF CONTAMINANT LEVELS AND BIOEFFECTS IN FISH-EATING BIRDS ON THE GREAT LAKES: III. BREEDING BIOLOGY OF HERRING GULLS AND FORSTER'S TERNS IN THE DETROIT/ST. CLAIR RIVER CORRIDOR - (Dr. D.V. Chip Weseloh)

Introduction. When wildlife populations show biological conditions that are often associated with high chemical contamination, it is important to study those situations more intensively. Herring Gulls on Fighting Island, in the Detroit River, periodically show extended egg laying periods, egg disappearance and, occasionally, reduced reproductive success. Similarly, poor hatchability and reduced reproductive success have been identified with specific levels of contamination in Forster's Terns in Green Bay. We propose to study the Herring Gull population on Fighting Island and the Forster's Tern population at Walpole Island (the largest in Ontario) to more accurately quantify and investigate these conditions.

The objective of this study was to determine the breeding biology parameters of Herring Gulls on Fighting Island and of Forster's Terns on Walpole Island.

Methodology. Daily visitations were made to the nesting colonies. Fresh eggs were collected for contaminant analysis. Nest contents, incidences of predation and egg fate were recorded; egg laying intervals were calculated.

Results and Discussion. Egg-laying intervals, colony synchrony, hatching success and parental attentiveness of Herring Gulls on Fighting Island in 1988 was within the usual range for this species. However, predation was quite severe with over 25% of the clutches partially or completely destroyed. Predation by muskrats and Ruddy Turnstones was observed; Fox Snakes were present but no signs of predation by them were observed.

Very early nesting by the Forster's Terns and difficulty obtaining the necessary access permission caused us to abandon the study on Walpole Island.

For further information, contact:

Dr. D.V. Chip Weseloh
Canadian Wildlife Service
Box 5050
Canada Centre for Inland Waters
Burlington, Ontario
L7R 4A6

(416) 968-7251

17. WILDLIFE AND AGRICULTURAL PESTICIDES IN SOUTHERN ONTARIO: BREEDING BIOLOGY PARAMETERS OF SWALLOWS, BLUEBIRDS, AND KESTRELS NESTING NEAR APPLE ORCHARDS ALONG THE NIAGARA ESCARPMENT - (DR. D.V. Chip Weseloh)

Introduction. Apple orchards are one of the most intensively sprayed crops in Ontario with applications of one or another compound as often as once per week. Orchards are thus a logical first place to look for any adverse effects of agricultural pesticide spraying upon wildlife. Therefore, an intensive two year field study was proposed to monitor bird, mammal, earthworm, and insect populations exposed to "spray events" in apple orchards in southern Ontario.

The objectives of this study were to determine:

1) the breeding biology parameters of nest box populations of Tree Swallows, Eastern Bluebirds, and American Kestrels near apple orchards in the Regional Municipality of Hamilton-Wentworth;

2) organochlorine levels in the eggs of the above species;

3) the comparative usefulness of the above three species as indicator species of exposure to agricultural organophosphate chemicals; and

4) the feasibility of a long-term chemical and/or biological monitoring program of the impact of modern agricultural chemicals on wildlife.

Methodology. Field data were collected and analyzed under contract.

Results and Discussion. Nest success and chick growth of bluebirds and swallows using the orchard nest boxes were compiled in a contractor's report. However, no data were collected from kestrels since only one of the orchard nest boxes was occupied. Schedules of spraying operations were collected from the co-operating farmers. A second report contains a summary of the information on pesticide use provided by the farmers, and a preliminary analysis of the nesting success data. The results indicated that the proportion of tree swallow eggs that did not hatch may have been higher in orchards where pesticides were used. Small sample sizes precluded a similar comparison for bluebirds. Nest data will be collected again to increase sample sizes enough to draw firm conclusions. No analysis of AChE levels was done to measure sublethal impacts of OP's but further collections will be planned.

Eggs collected were analyzed in pooled samples for OC's by the National Wildlife Research Centre (NWRC). Results for all 3 species (swallows, bluebirds, and kestrels) indicated that DDE levels were much higher in eggs from the Niagara Peninsula than in eggs from the other areas sampled in southern and central Ontario.

Evaluation of the usefulness of the species as indicators of agricultural impacts will have to await the collection of a second year of data.

For further information, contact:

Dr. D.V. Chip Weseloh
Canadian Wildlife Service
Box 5050
Canada Centre for Inland Waters
Burlington, Ontario
L7R 4A6

(416) 968-7251

PESTICIDES PROGRAM IN THE WESTERN AND NORTHERN REGION

(Alberta, Saskatchewan, Manitoba, Northwest Territories)

1. ELIE AQUIFER RECHARGE PROJECT - (Wendy Tibbatts, Environment Canada; and Dennis Brown, Manitoba Environment)

Introduction. The town of Elie in the rural municipality of Cartier in Manitoba relies on a small lens of high quality water overlying a larger aquifer of much poorer, saline water. As the water demands in the area have increased, this small Elie aquifer is being depleted, and briny seepage from the larger aquifer is steadily reducing the quality of the water, since natural recharge cannot keep pace with water use. Artificial recharge with water from the nearby La Salle River was proposed a number of years ago, and ditches and culverts were put in place at that time to allow water pumped from the river to flow into the gravel pit overlying the water lens. This project was halted, however, since water from the La Salle was found to have trace pesticide contamination, especially in the spring runoff period. At that time, this was the only period during the year when recharge was considered, since later in the season, river flow was unpredictable, especially during dry years.

Since then, the La Salle River has been augmented by flow from the larger Assiniboine, assuring year-round flows. This would provide water volumes large enough to allow artificial recharge in the late summer, and early fall, should a window of pesticide free water be found, presumably after spring herbicide, and summer insecticide spraying was long finished, and before fall spraying began.

The objectives of this study were to determine if a "window" in the quality of the La Salle River occurs in the later summer and early fall, such that the risk of pesticide contamination could be minimized if artificial recharge to the Elie aquifer took place.

To determine the effect of the Assiniboine River diversion on the water quality of the La Salle River.

Methodology. Samples were taken for general inorganic and physical parameters, microbiological parameters, and insecticide and herbicide analyses, three times a week, from August 29 to September 15, 1988. During this time, temporary pumps were installed on the La Salle River to pump water into the drainage ditch as it would be done if recharge was occurring, with a block at the final diversion point into the recharge gravel pit. This simulated actual recharge to the greatest extent possible without actually pumping water into the recharge area. The site furthest upstream was on the Assiniboine River, just before water is pumped from there into a ditch leading to the la Salle River, the second and third were on the La Salle, and the final site was in the recharge drainage ditch just at the block. After September 15, the pumps to the recharge ditch were turned off, and samples were taken once every two weeks, at only the first three sampling sites.

Herbicide samples were taken from the aquifer itself once during the study period from three observation wells already present.

Results and Discussion. Most inorganic and physical parameters showed an improvement in water quality as the water flowed upstream. All parameters were within Canadian Drinking Water Guidelines, and were an improvement above raw water being taken from the well. Nitrate concentration in particular was consistently below detection limit at the final site. The one exception was the colour parameter, which was above the guideline, probably as a result of the water flowing slowly through ditches with drying grasses and plants. Although hardness was also above the guideline, it was no worse than the raw water, which is already being softened.

The microbiological parameters were unexpectedly and inexplicably high, and recharge would not take place if this were verified to occur consistently. These values are presently under investigation.

There were no insecticide hits during the entire sampling period. Triallate, a herbicide, was detected four times during the sampling period (0.176 to 1.191 µg/L), from September 11 until

September 27. 2,4-D was detected once on October 11 (1.407). No other pesticides were detected in the surface water, although bromoxynil contamination was found in the aquifer (0.098 µg/L). This confirms provincial environment data that shows bromoxynil has been present in the aquifer for some years. It does appear that a window of reduced pesticide risk contamination occurred from at least the start of the intensive sampling period (August 29, 1988) until September 8, 1988. This would be a sufficient time frame to recharge up to a year's supply of water for the town. This would not be a consistent time frame every year, and would not allow for a zero-risk scenario.

This study will be used by decision-making bodies (Manitoba Environment, Manitoba Water Services Board, Manitoba Health) to determine if artificial recharge can be considered, and what pre-treatment might be necessary. If artificial recharge is not undertaken, water supply demands will have to be met in other ways at considerable more expense, and probably within three years or less.

A draft report is under review.

For more information, contact:

Wendy Tibbatts
Manitoba District Office
Environmental Protection
Environment Canada
5th Floor, 269 Main Street
Winnipeg, Manitoba
R3C 1B2

(204) 983-7788

2. MONITORING DEPOSIT OF DELTAMETHRIN IN PRAIRIE WETLANDS BY AERIAL APPLICATORS - (DR. D.J. Forsyth, Canadian Wildlife Service, Saskatoon; Dr. D.C.G. Muir, Fisheries and Oceans Canada, Winnipeg)

Introduction. It is likely that insecticides, such as deltamethrin and others (carbaryl and chlorpyrifos) that are highly toxic to aquatic invertebrates enter the water of prairie slough by direct deposit and drift. Avoidance of sloughs by spray pilots is impractical or impossible where numerous small sloughs are scattered throughout the cropland. Deltamethrin has been shown to reduce populations of invertebrates important as food for ducklings by at least 95%; consequently, ducklings would be forced to move to different sloughs which could in turn be similarly depleted by spray application. No data exist to document the extent to which aerial applicators avoid small bodies of water in cropland.

The objective of this study was to determine the extent to which aerial application of deltamethrin results in contamination of slough waters.

Methodology. A series of 50 wetlands located in canola fields was selected by driving through the main canola-growing areas of Saskatchewan. When aerial spraying for control of diamondback moth in canola began in mid-July, farmers whose canola fields included wetlands were contacted by telephone to determine whether or not they had sprayed or intended to spray their crops. Samples of water were collected from sloughs that had been sprayed.

Results and Discussion. Extreme drought conditions made the task of locating 50 sloughs in canola fields very difficult. High temperatures resulted in deltamethrin not being the insecticide of choice for diamondback moth control. The region in which most of the sloughs were located was reportedly not sprayed. Water samples were collected from three sloughs that had been sprayed with malathion. Chemical analysis of the water samples did not detect any insecticide. The 50 sloughs that were located in canola cropland have been mapped for future reference.

For more information, contact:

D.J. Forsyth
Canadian Wildlife Service
115 Perimeter Road
Saskatoon, Saskatchewan
S7N 0X4

(306) 975-5065

3. PESTICIDE INVESTIGATIONS IN GROUNDWATER BENEATH AN IRRIGATED FIELD NEAR OUTLOOK, SASKATCHEWAN - (D. McNaughton, NHRI; R. Grover, Agriculture Canada, and W. Nicholaichuk, NHRI)

Introduction. This project began in 1986 as a cooperative effort between NHRI's Dr. Nicholairchuk, Dr. Whiting of the Saskatchewan Research Council, and Dr. Grover of Agriculture Canada. It was initially conceived as a study of the loss of herbicide and nutrients off an irrigated field. A cursory investigation of groundwater quality during this investigation, however, pointed up a measurable concentration of the herbicide dicamba in a shallow ABS plastic observation well.

A groundwater study, funded in part by PESTFUND, and by NHRI A-base resources was begun in 1987-88, and culminated in an interim report submitted to PESTFUND management later in early 1988. This was a survey type of study, and focussed quite broadly, on three separate study areas near Outlook. The work involved installation of observation wells on two of these sites, and the analysis of groundwater samples by Dr. Grover's laboratory in Regina. The study results, while interesting, were inconclusive, owing mostly to the lack of spatial or temporal constancy in pesticide detections in the groundwaters from the three sites, and the limited amount of time-series data which could be accommodated, due to resource considerations. Essentially, the resources available were spread too thin for anything but a very broad approach. Further work was therefore contemplated.

The project is designed to gain some understanding of the amount of pesticide reaching the groundwater zone under irrigated prairie conditions, and to understand more about the hydrogeologic controls to downward pesticide movement under these conditions. The irrigation of a field will tend to accelerate the leaching of pesticides to the water table, so that to some extent, the site selected for the 1988-89 work can be considered a worst case.

Methodology. The data collected from this study were gathered by conventional field and laboratory techniques, including: drilling, logging, water level measurement in the field, chemical analyses of water samples for major ions and pesticides, and the use of models to explain the observed data. During the summer of 1988, further groundwater sampling was conducted from observation wells drilled in 1987 on the Pederson Site. To correct problems encountered in 1987 with too many sampling points, a smaller number of observation wells were monitored in order that a larger number of samples could be collected from each well over the growing season and fall. Samples were analyzed in the laboratory of Dr. R. Grover at the Agriculture Canada Research Station, Regina.

In addition to groundwater sampling, the NHRI Hydrology Research Division installed a series of suction tensiometers on the field, and these were sampled over the same period of time as the groundwaters.

Results and Discussion. The sampling program was carried out in order to confirm data received in 1987, which showed that even beneath an irrigated field, the levels of observed pesticide in groundwater were quite small, and inconstant over space and time. While the location and timing of positive detections from the site were still somewhat unpredictable, the 1988 results confirm that the pesticides diclofop-methyl, bromoxynil, 2,4-D are capable of reaching the saturated zone under these conditions, albeit in small concentrations.

The tensiometers showed a good correlation of detected concentration (the same three pesticides) with depth, indicating that these compounds do in fact carry down into the unsaturated zone, and that some kind of transport through the unsaturated zone is responsible for the various detections in the saturated zone.

Of particular interest at the Pederson Site were the hydrographs of the observation wells and the relation of these to the geology. Some of the hydrographs seem to indicate fracture flow

through surficial silts, and this characteristic response is generally correlatable with a larger number of pesticide detections in affected observation wells.

For more information, contact:

G. Grove
National Hydrology Research Institute
(NHRI)
11 Innovation Boulevard
Saskatoon, Saskatchewan
S7N 3H5

(306) 975-5735

W. Nicholaichuk
(same address)

(306) 975-5748

R. Grover
Agriculture Canada
Regina Research Station
5000 Wascana Parkway
Regina, Saskatchewan
S4P 3A2

(306) 780-7400

4. RE-EVALUATION OF IN-USE PESTICIDES - (Miles Constable, Walter Golebiowski, Jayesh Bharadia, Environmental Protection, Western and Northern Region)

Introduction. Re-evaluation is a review of all registered uses of pesticide active ingredients and the data supporting these uses in the light of current knowledge and concerns. It is a substantially different process from the review and registration of a new product. The purpose of re-evaluation is to:

1) identify and fill data gaps, bringing older data bases up to modern standards;

2) identify and examine concerns regarding human safety or adverse environmental effects;

3) ensure continued efficacy; and

4) take the appropriate regulatory steps to remove those products which are no longer effective or no longer meet the requirements of Section 19 of the *Pest Control Products Act*.

The objective of this study is to ensure that priority pesticides in the region do not pose a hazard to the environment with present application practices. Where it is determined that a pesticide may pose a hazard to the environment, it is the regional office's duty to identify the potential hazard to EP-HQ and to advocate that the concern be addressed by the re-evaluation process. Concerns will be addressed directly by either the manufacturer or by Agriculture Canada. EP will do only what is necessary to show that there is reasonable potential for a pesticide to harm the environment.

Methodology. Literature on each pesticide will be searched by computer (via Dialogue and Chemical Information Systems) to collect recent research data. This should fill data gaps on registered pesticides, and may identify areas of serious environmental concern for those pesticides with outdated data bases.

Any pesticides having insufficient environmental information will be addressed in a further effort to find relevant information. Only after this second attempt will such a lack of data be considered to be worthy of regional concern, and communication to Ottawa.

Data analysis will consist of four basic techniques to determine areas of potential concern for EP to focus on:

- comparison of related data,
- applicability of the data to the northern Great Plains,
- comparison of research data with registration data, and
- absence of research and registration data.

The concerns produced by the regional review of data will be divided into two groups: minor ones that could be addressed within the region by research or assessment projects by EP and/or other agencies, and those that should be addressed by the industry or an industry/government task force. Those concerns addressable within the region will be related to minor aspects of the environmental data that need to be cleared up to satisfy EP that the pesticide in question does or does not pose an environmental risk. Which agency does the work is a matter of mandate and negotiation between EP and the other regional C&P agencies. C&P agencies will not undertake major research efforts to prove a chemical is safe to use, this is the responsibility of the manufacturer. Concerns that are clearly industry responsibilities will be communicated to EP-HQ and from there to Agriculture Canada. It will be a matter of negotiation between the headquarters staff of EP and Agriculture Canada as to how the concern will be addressed.

Results and Discussion. To date reports have been produced on MCPA, glyphosate, difenzoquat, triallate, pentachlorophenol, and creosote. Other reports in progress are on dimethoate, carbaryl and chlorpyrifos.

MCPA is a herbicide in wide use on the prairies due to its continued efficacy and low price. The environmental concerns regarding its continued use are not major, work needs to be done to modernize the data base with respect to acute and chronic toxicity to a variety of aquatic organisms to ensure that toxicity values generated in the past are accurate. There is a lack of environmental monitoring programs for pesticides in air and groundwater, however, this is not specific to MCPA.

Glyphosate (Roundup, Vision, Sidekick, Clear-It) is a popular herbicide increasing in use on the prairies for agricultural, forestry and domestic use. It is highly toxic to most plants, except for coniferous trees (spruce, pine, fir, etc.), that makes it ideal for forestry use. Its toxicity to animals of all kinds is very low. Any herbicide that reaches the soil is bound so tightly that it is rendered ineffective and does not leach from the soil. The environmental concerns regarding its use are not major. Forestry tests have conclusively proven that buffer zones along streams will prevent the contamination of the water when using glyphosate for forestry purposes. Work needs to be done to define typical soil degradation rates in prairie farm and forest soils and the toxicity to the soil microbial community has not been well defined. Degradation of glyphosate in freshwater sediments is slow, fortunately the herbicide has a low toxicity and does not leach out of the sediments once bound to them. A major problem is the analysis of glyphosate in environmental media, it is time consuming, difficult and costly.

Difenzoquat* (Avenge) is a popular herbicide for the control of wild oats in cereal crops. So little environmental data was available in the scientific literature that no assessment of its behaviour could be done. It appears to have low toxicity to most aquatic and terrestrial animals. It is strongly bound to soil so that little will evaporate or run off, although it may persist there for long periods. In general, much work needs to be done on difenzoquat to define its environmental behaviour.

Triallate (Avadex BW) is a popular herbicide for the control of wild oats in cereal crops. Its use has declined considerably in recent years, possibly due to the use of alternative herbicides and a reduction in pesticide use by farmers facing poor economic conditions. Triallate is highly toxic to aquatic life of all kinds, but is not very toxic to mammals or birds. It has been found in many small streams in rural areas, in precipitation and in air. It is bound tightly to the soil until it rains, then considerable quantities can evaporate from the soil. Chronic toxicity data indicates triallate is highly toxic to aquatic arthropods, further work needs to be done to determine if it is a threat to aquatic wildlife. The use of buffer zones along streams in agricultural areas would likely reduce the contamination of valuable wildlife habitat. Evidence of bioaccumulation of triallate in forage fish requires further work to define the situation. Groundwater contamination in irrigated areas also requires further work.

Pentachlorophenol (PCP) is a wood preservative used for the preservation of industrial timbers and utility poles. Recent restrictions on its use has limited it to industrial wood products. Contamination of PCP by polychlorinated dibenzodioxins and furans has created much concern in environmental agencies as some forms of dioxins and furans are extremely toxic. No 2,3,7,8-tetrachlorodibenzodioxin has been found in PCP marketed in Canada. PCP is extremely toxic to all forms of aquatic life. Some fish kills in British Columbia have been attributed to PCP and sodium PCP. Toxicity to other animals is moderately high, but not a major concern because the major problem associated with PCP use has been site contamination of streams and groundwater at wood-treating facilities. Agriculture Canada has developed risk reduction strategies for PCP. Environment Canada has developed operating guidelines for wood-treating facilities to eliminate the water contamination problems. Discussions with the wood-treating industry on implementing these guidelines are ongoing.

---

* The common name for Avenge is difenzoquat methyl sulphate.

Creosote is a wood preservative composed of 300 to 10 000 different compounds, many of which are highly toxic, and some of which are mutagenic. It is a diverse mixture of polyaromatic hydrocarbons, tar acids, tar bases, and miscellaneous petroleum products that can only be generally characterized for environmental assessment purposes. Each chemical in the mixture has its own chemical properties and behaviour in the environment. Registered uses include heavy industrial timber preservation and remedial treatments for timbers and railroad ties. There is concern by environmental agencies that the continued use of creosote may have an unacceptable risk to the environment. In the past, sloppy treating practices in Canada and other countries have created environmental hazards. Creosote-treated wood is regulated under the *Hazardous Products Act*. Creosote is registered under the *Pest Control Products Act* as a wood preservative pesticide. Creosote-impregnated waste materials are listed in Group 2 of the Priority Substances List of Environment Canada's *Canadian Environmental Protection Act (CEPA)*, and as such will undergo an assessment under *CEPA*. Environment Canada has developed wood-treating guidelines for the industry and is presently considering mandatory adoption of these guidelines. Environment Canada and the Canadian Institute of Treated Wood plan to assess conditions at wood-treating plants and determine where improvements can be made to prevent contamination at those sites.

For more information, contact:

Miles Constable
Environmental Protection
Western and Northern Region
Environment Canada
4999 - 98 Ave.
Edmonton, Alberta
T6B 2X3

(403) 468-8038

5. EFFECTS OF BRAN-BAIT PESTICIDE FORMULATIONS ON NON-TARGET ORGANISMS - (B.H. Thompson (Environment Canada, Alberta District Office, Edmonton))

Introduction. The objective of this joint venture with Agriculture Canada, is to assess the environmental cost/benefits of a new delivery mechanism for pesticides to be used during grasshopper outbreaks on the prairies. So far, the following has been accomplished:

1. field trials on carbaryl bran-bait completed and analyzed;
2. one mouse laboratory feeding trial completed and analyzed (three formulations);
3. two Tenebrio (beetle) exposure trials completed and analyzed (three formulations);
4. two leafcutter bee exposure trials completed and analyzed (three formulations);
5. *Folsomia* (springtail) laboratory rearing/exposure method developed; lab colony established;
6. five fish bioassays completed and analyzed;
7. one *Daphnia* mobility trial completed; and
8. chemistry work on leaching rates completed and analyzed.

Results and Discussion. From the field trials, it appears that Carabid beetles of one common genus may have been negatively affected by the carbaryl bran-bait formulation. Apart from this, however, no evidence was obtained indicating effects on other ground-dwelling arthropods.

So far, lab results have yielded useful information on the effects of three active ingredients incorporated into bran bait (one is registered) on non-target organisms. In trials examining lethal/non-lethal effects on selected non-target organisms at various trophic levels, when exposed to, or offered rations of, the bait, the results suggest that at least one of the formulations represents an ideal means of applying grasshopper control chemicals. Particularly interesting were the efforts made to establish a bee colony and develop a testing protocol. This is a high-profile issue with farmers vis-a-vis grasshopper control programs. The comparison of different bran-bait products is of special interest to Agriculture Canada.

The second phase will compare conventional spray formulations side by side with bran-bait formulations, using the same active ingredient. The testing protocols developed should enable a definitive evaluation to be made. This is the fundamental problem of interest to Environment Canada.

Five laboratory bioassays using rainbow trout, were performed on both carbaryl and chlorpyrifos-treated baits. At the highest concentration, (1.0 g of formulation per test tank), definite effects in terms of stress and mortality were observed. Chlorpyrifos-treated bait appeared to have a greater effect than did carbaryl-treated bait. At the lowest dosage (0.01 g per tank), no change in behaviour or mortality was seen for either formulation. For intermediate dosages, significant stress was noted with chlorpyrifos bait, but not with carbaryl. Exposure trials using *Daphnia* (a suspension- feeding organism) have begun.

In the EP organic chemistry lab, trials were carried out to examine the effects of temperature, agitation and pH on the rate at which active ingredient leached out of immersed bran-bait. Carbaryl had a greater tendency to enter water (more than 50%) than did chlorpyrifos (less than 20%). Leaching of chlorpyrifos increased with temperature, but carbaryl did not show such a relationship. Leaching of carbaryl decreased with increased pH.

For more information, contact:

Bruce H. Thompson
Alberta District Office
Environmental Protection
Environment Canada
4999 - 98 Avenue
Edmonton, Alberta
T6B 2X3

(403) 468-8008

6. FATE AND EFFECT OF DICLOFOP-METHYL IN AN AQUATIC MICROCOSM - (S. Swanson and D. Lintott, Saskatchewan Research Council)

Introduction. Diclofop-methyl, (methyl (RS)-2-(4-[2,4-dichlorophenoxy) phenoxy] propionate, registered as Hoe-Grass herbicide in Canada, is widely used on the prairies for the control of wild oats, foxtails and other weeds in wheat, barley, and flax. Residues of the acid metabolite of diclofop-methyl have been observed in a variety of aquatic samples, indicating widespread transport into the aquatic environment. Little or no research data are currently available, however, on the behaviour and fate of this phenoxypropionic herbicide in the aquatic environment. No data are available on the toxicity of this herbicide in a "typical" aquatic ecosystem. Published data show diclofop-methyl is relatively toxic to individual aquatic species. The 96-h LC_{50} for the rainbow trout of 1.38 mg/L. The same toxicity endpoint for carp was reported to be 2.6 mg/L. A 48-h LC_{50} for *Daphnia* was 4.03 mg/L. Because diclofop-methyl can reach aquatic environments following application and is relatively toxic to at least some aquatic species, this study was initiated to determine the distribution, degradation, toxicity, and bioaccumulation potential of diclofop-methyl in an aquatic model ecosystem.

Methodology. The first part of this investigation obtained the relevant scientific and technical information regarding diclofop-methyl from the literature. From this information, the expected behaviour of the compound in the aquatic ecosystem was derived and the experimental protocols for both the toxicological investigations and the mass transport studies were designed. Toxicity tests were conducted on selected planktonic and benthic organisms (*Daphnia magna*, *Hyalella azteca*, *Cypridopsis* spp., rainbow trout, algae). The general methodology for these investigations included single-species toxicity tests and aquatic microcosm fate and toxicity tests using ^{14}C-radiolabelled diclofop-methyl.

Results and Discussions. The preliminary study was initiated to determine the effect a reference toxicant (copper) would have on the model ecosystem (the Standardized Aquatic Microcosm). This test confirmed that the microcosms were performing within acceptable limits for adequate quality control criteria. Following this, single-species toxicity tests using *Daphnia magna*, *Hyallela azteca* (an amphipod), and 10 algal species were conducted. The EC_{50}s for the algal species ranged from 1000 to 5000 µg/L. The 48-h LC_{50} for *Daphnia magna* was between 100 and 200 µg/L, and the 48-h LC_{50} for *H. azteca* was between 100 and 500 µg/L. Further tests are now being conducted with narrower ranges of contaminant concentrations to obtain definitive LC_{50}s. In addition, work now being conducted includes single-species tests using *Cypridopsis* (an ostracod), 96-h acute LC_{50} investigations with rainbow trout fingerlings, and partitioning tests (solubility of acid/ester; adsorption to sediment; pKa determination; hydrolysis rate; K_{ow}) and concurrent fate/bioaccumulation tests using ^{14}C-labelled diclofop-methyl.

For more information, contact:

M. Wong
Water Quality Objectives Division
Water Quality Branch
Ottawa, Ontario
K1A 0H3

(819) 953-3197

Wm. Gummer
Water Quality Branch
Regina, Saskatchewan
S4P 3R4

(306) 780-5322

7. CHRONIC TOXICITY OF LINDANE, TRIALLATE, AND TRIFLURALIN TO FATHEAD MINNOWS AND *Ceriodaphnia dubia* - (Walter Golebiowski, Environmental Protection, Western and Northern Region, Gordon Craig, Beak Consultants Ltd.)

Introduction. The agricultural pesticides lindane, triallate and trifluralin have been identified by Environment Canada for post-registration environmental fate/effects monitoring on the Canadian prairies. Concerns exist pertaining to their potential adverse impacts on non-target aquatic organisms, under regional environmental conditions. Concerns are based on their high regional sales and their high aquatic toxicity (acute lethality) values, as reported in the literature. Regional surface water pesticide monitoring programs (Environment Canada, Department of Fisheries and Oceans and Manitoba Environment) have detected these pesticides in various major surface water systems, at sublethal concentrations. One of these pesticides, trifluralin, has been found to accumulate in fish and other aquatic species at these sublethal concentrations. Few scientific investigations into the sublethal (chronic) toxicity of these pesticides to native (Canadian prairie) aquatic organisms have been reported, and significant knowledge gaps exist. There is sufficient general evidence in the literature, however, to suggest that the potential exists for chronic adverse effects on aquatic organisms exposed to these pesticides.

Objective of this study, using laboratory experiments was to evaluate, the sublethal toxicity of these three pesticides to two standard indicator test organisms, thereby rendering novel and significant information which contributed to filling these data gaps.

Methodology. The three pesticides to be tested were:

1) Lindane (gamma-HCH) (insecticide)

2) Triallate (herbicide)

3) Trifluralin (herbicide)

Technical grade samples of the three pesticides were supplied by Environmental Protection, Edmonton. Given the low water solubility of these pesticides, stock solutions were prepared by the consultant, by dissolving the technical grade pesticides received in an acceptable solvent such as acetone. Each pesticide was tested by performing bioassays on the following test species:

1) *Ceriodaphnia dubia* - freshwater invertebrate survival/inhibition tests,

2) *Pimephales promelas* - fathead minnow larval growth inhibition tests.

These indicator organisms are widely used in aquatic toxicity evaluations, are used in accepted and standardized test protocols, and are representative of species endemic to the regional surface water in question.

Standard quality assurance/quality control (QA/QC) procedures were followed for all tests, including the use of appropriate clean controls and solvent controls.

1) Aquatic Bioassays

i) Rangefinding Tests:
In the absence of any existing relevant data on the toxicity of the three pesticides, rangefinding tests were conducted initially for each pesticide using each of the two organisms. These abbreviated (i.e., four concentrations/no replication) tests assisted in more accurately identifying the upper and lower limits for the range of concentrations tested in the definitive bioassays to determine the actual LC_{50}/EC_{50}s. Testing was performed under the same conditions (light, temperature, etc.) as the actual bioassays.

ii) *Ceriodaphnia dubia* Bioassay:
The chronic life-cycle test using *Ceriodaphnia* was conducted according to the U.S. EPA (1985) protocol. At the end of the test, data were pooled

and the LC_{50} was determined based on survival of test organisms and the EC_{50}, No Observable Effect Concentration (NOEC), Lowest Observable Effect Concentration (LOEC) and the Chronic Value (ChV) as per the EPA, 1985 protocol were statistically (i.e., Fisher's Exact Test, ANOVA and Dunnett's procedure) determined from the numbers of offspring produced, in both nominal and actual concentrations.

iii) Fathead minnow (*Pimephales promelas*) Bioassay:
The 7-day static-renewal bioassay using fathead minnow was conducted in accordance with the U.S. EPA (1985) protocol. LC_{50}s and EC_{50}s, as well as the NOEC, LOEC, and ChV were determined statistically (i.e., Spearman-Karber, Dunnett's procedure, etc.) for survival and growth, in both nominal and actual concentrations.

Results and Discussion. Lindane was more acutely and chronically toxic to *Ceriodaphnia dubia* than to fathead minnows (*Pimephales promelas*). The 7-day LC_{50} for *Ceriodaphnia dubia* was 56 µg/L, the NOEC was 6.6 µg/L, the LOEC was 10.5 µg/L and the chronic value was 8.3 µg/L. In *Pimephales promelas* lindane exhibited a 7-day LC_{50} of 112 µg/L, a NOEC of 45 µg/L, a LOEC of 72 µg/L and a chronic value of 57 µg/L. From these data lindane would not be expected to be chronically toxic at the present ambient concentrations in western Canadian rivers (0.001 to 0.02 µg/L).

Triallate was also more acutely and chronically toxic to *Ceriodaphnia dubia* than to *Pimephales promelas*, by two orders of magnitude in the chronic tests. The 7-day LC_{50} for *Ceriodaphnia dubia* was 12 µg/L, the NOEC was 1.3 µg/L, the LOEC was 2.4 µg/L and the chronic value was 1.8 µg/L. Triallate exhibited toxicity values of 330 µg/L in the 7-day LC_{50} test, 125 µg/L for the NOEC, 202 µg/L for the LOEC and 160 µg/L for the chronic value in *Pimephales promelas*. This data indicates that some residues in western Canadian rivers could be chronically toxic to aquatic invertebrates, although they would not likely be acutely toxic, especially to fish.

Trifluralin, unlike the other two pesticides, was more acutely and chronically toxic to the fathead minnow than to *Ceriodaphnia dubia*. Minnows exhibited a 7-day LC_{50} value of 21 µg/L, a NOEC value of 4.3 µg/L, a LOEC value of 11 µg/L, and a chronic value of 6.9 µg/L. *Ceriodaphnia dubia* had a 7-day LC_{50} of 63 µg/L, a NOEC of 19 µg/L, a LOEC of 49 µg/L, and a chronic value of 31 µg/L. This data indicates that trifluratin could be a potential hazard to the growth of juvenile fish.

This work is being prepared for publication in a scientific journal, citation of these results may be premature.

For more information, contact:

Miles Constable
Environmental Protection
Western and Northern Region
Environment Canada
4999 - 98 Ave.
Edmonton, Alberta
T6B 2X3

(403) 468-8038

8. TOXICITY OF CARBOFURAN SPRAY TO MALLARD DUCKLINGS - (Dr. D.J. Forsyth, Canadian Wildlife Service, Saskatoon; Professors G.R.B. Webster and L.J. Shapiro, University of Manitoba, Winnipeg)

Introduction. Carbofuran is sprayed extensively by ground equipment and by aircraft to control grasshoppers along roadsides, in headlands, forage crops and pasture, all of which constitute nesting habitat for mallards, teal, pintail and other species of duck. Spraying for newly-hatched grasshoppers coincides with the hatching of duck eggs during the first three weeks of June, so that ducklings may be exposed to sprayed vegetation while walking from the nest to the water. The adult ducks may be exposed to sprayed vegetation during the three weeks of incubation. Movements of broods from one slough to another may also result in exposure. Waterfowl are highly sensitive to carbofuran; ducks have been killed in large numbers in alfalfa fields sprayed with carbofuran in the United States. No data exist for effects of this insecticide upon breeding populations in Canada. The objective of this study was to examine the toxic response of mallard ducklings to upland nesting habitat sprayed with carbofuran.

Methodology. Three groups of 15 ducklings were walked through vegetation paths of prairie grass sprayed with carbofuran at 140 g a.i./ha, the rate recommended for grasshopper control, by ground equipment. Distances walked by the ducklings through sprayed grass were 10, 50 and 100 m; no opportunity was provided to swim at the end of these exposures. Four ducklings per group were sacrificed for residue analysis at the end of each exposure. Two additional ducklings per group were taken for analysis two days after exposure, and another two at four days after exposure. Following exposure to the sprayed vegetation, ducklings were placed individually in an arena where they were tested for brood cohesiveness behaviour by allowing them to select among three sizes of groups of ducklings with which to associate.

Results and Discussion. In the first trial, using 48-h-old ducklings, mortalities that occurred during the day of treatment were, as fractions of 15-duckling samples, 0/15, 2/15, and 1/15 in the 10-m, 50-m and 100-m vegetation paths, respectively. In the second trial, using 96-h-old ducklings, mortalities during the day of treatment were 5/15 and 5/15 in the 50-m and 100-m paths. No further mortality occurred after the day of spraying. Ducklings were visibly disoriented and unsteady on their feet after exposure, but were able to select correctly in brood cohesiveness tests. Some loss of body mass among treated ducklings, compared to controls, was evident during two weeks after treatment. Analysis of the vegetation showed that more carbofuran was deposited than intended. Further trials will be carried out to increase distances walked by the ducklings and to ensure that spraying conforms to methods used in agriculture.

For more information, contact:

D.J. Forsyth
Canadian Wildlife Service
115 Perimeter Road
Saskatoon, Saskatchewan
S7N 0X4

(306) 975-4088

9. POTENTIAL SECONDARY POISONING HAZARD OF RODENTICIDES FOR BIRDS OF PREY IN ALBERTA - (DR. J.K. Schmutz, Contractor, Department of Biology, University of Saskatchewan, Saskatoon)

Introduction. Ground squirrels are regularly poisoned with strychnine bait in Alberta, a practice which could result in the poisoning of birds of prey that eat the dead squirrels or feed them to their young. Mortality of nestling hawks in southern Alberta occurs in about 30% of nests surveyed. Several cases of dead nestling hawks have been highly suggestive of poisoning. Ferruginous hawks are designated a "threatened" species in Canada; their breeding habitat in southern Alberta is in an area where poisoning of ground squirrels with strychnine is a common practice. The objective of this study was to determine if adult Swainson's hawks scavenge poisoned ground squirrels, and whether the strychnine content of poisoned ground squirrels is sufficient to kill nestling hawks.

Methodology. Swainson's hawks, which are common and increasing in numbers, were used as the test subjects. The carcasses of 180 ground squirrels killed by strychnine bait were placed in 25 nests at three times during nestling development. Rate of feeding by parents and nestlings was monitored by repeated visits to the nests. Three poisoned ground squirrel carcasses were placed on the surface of the ground 100 m from five hawk nests and monitored to determine whether hawks use them for food.

Results and Discussion. Three of the total 58 nestlings that consumed carcasses of poisoned ground squirrels died, whereas no mortality occurred among control nestlings. Survival of the experimental nestlings to 20 to 40 days of age was 72%, compared to 82% survival among control nestlings. No effect of treatment was detected or gain in body mass of nestlings. The investigator concluded that there is minimal hazard, if any, to birds of prey from eating strychnine-poisoned ground squirrels.

For more information, contact:

Dr. Geoffrey Holroyd
Canadian Wildlife Service
4999 - 98 Avenue
Edmonton, Alberta
T6B 2X3

(403) 468-8922

10. FEASIBILITY OF USING BLUEBIRD TRAILS TO MONITOR THE EFFECTS OF INSECTICIDES ON SONGBIRDS - (Louise Horstman, Contractor, Pecan Resources, Inc., Morinville, Alberta)

Introduction. Songbirds can be poisoned by insecticides used to control grasshoppers, cutworms, flea beetles or other insects in agricultural crops. Chemicals such as carbofuran, chlorpyrifos, demeton, and others can be ingested by birds eating sprayed insects or vegetation, by inhalation, preening of contaminated feathers, or absorption through the feet. Bluebird nest boxes may be situated next to cropland, and since these birds are insectivorous, feeding on grasshoppers, beetles and other ground-dwelling insects, the risk of poisoning seems high. Spray drift could be monitored by placing passive air samplers on selected nest boxes. A network of volunteer ornithologists monitoring this type of off-target effect could potentially provide additional information about effects of insecticides.

The objective of this study was to evaluate the feasibility of using bluebird trails to monitor effects of insecticides by:

(a) summarizing locations of trails, numbers of nest boxes and associated crop types;

(b) determining the kinds of data obtainable from trail operators; and

(c) soliciting cooperation of volunteer trail operators in data collection.

Methodology. A total of 178 bluebird trails was investigated across the prairie provinces for suitability in a monitoring program. Volunteer trail monitors were interviewed and trails were driven to determine the type of associated habitat.

Results and Discussion. Trail monitors visit nest boxes during the breeding season from as seldom as twice (20%) to as frequently as every week (19%), with an average frequency of four to six visits (39%). The majority of monitors indicated willingness to cooperate in gathering data for CWS that could be used to monitor the effects of insecticides on nest box inhabitants. The most common species utilizing nest boxes is the tree swallow (55% of all occupied boxes), followed by the mountain bluebird (31% of occupied boxes). Most bluebird nest boxes are located next to pasture, because of the belief that the birds prefer low-growing vegetation for foraging; however, a significant number of trails are situated next to cropland.

The report from the contractor, including 26 topographic maps, 1:250,000 scale, showing locations of all trials investigated, recommends that tree swallows and mountain bluebirds be the species monitored, and that trail monitors be provided with data booklets designed to record data on a weekly basis for clutch size, hatching success, adult mortality or desertion, fledging success, weather information and pesticide application information. The study showed that there are sufficient numbers of bluebird trails located close to crops that could be sprayed with insecticide to serve as a system of monitoring for effects on passerines.

The monitoring system should be initiated, especially in view of the potential for broad scale spaying of wheat as the Russian wheat aphid spreads further north.

For more information, contact:

D.J. Forsyth
(Scientific Authority)
Canadian Wildlife Service
115 Perimeter Road
Saskatoon, Saskatchewan
S7N 0X4

(306) 975-5065

11. EXTRACTABILITY OF FOUR HERBICIDES FROM PASSIVE ORGANIC VAPOUR MONITORS (OVMs) - (Gary Bruns, Enviro-Test Laboratories, Edmonton, Alberta; and Miles Constable, Environmental Protection, Environment Canada, Edmonton)

Introduction. Pesticide contamination of the Canadian prairie air has been well documented. The prime sources of contamination are off-target drift of herbicides during application and evaporation of herbicides shortly after application. With present techniques, sampling of these airborne pesticide residues is expensive, difficult, and time consuming. What is required is an inexpensive, simple, and accurate sampling methodology for airborne pesticides.

Flow-through air samplers have some major drawbacks when setting up a multi-station monitoring system. They are expensive to purchase, require a source of electricity (either AC line current or DC battery current), the vacuum pump must be calibrated, and the sampling rate must be experimentally determined to avoid pesticide breakthrough of the sampling media. Battery-powered systems have the additional problem of not being able to provide the long-term sampling required for low levels of ambient pesticide vapours. Passive monitors have potential for environmental monitoring purposes. They are relatively inexpensive, quickly set up, sensitive to organic vapours, not subject to calibration requirements, easy to use, and capable of providing continual sampling and reproducible results. Their major drawbacks are that they have not been validated for outdoor, long-term monitoring or for the monitoring of pesticides. Many industrial chemicals are sampled with these devices, but monitoring, extraction and analytical methodologies for most pesticides have not been developed by their manufacturers. Organic vapour monitors have proven to be effective at detecting very low levels (ng/m^3) of organic vapours when used in telephone switching stations for up to a month. Benzene vapours in ambient air have been monitored effectively with OVMs. Many pesticides in use today have a benzene ring as their molecular base, so in the vapour phase they should adsorb onto the activated charcoal of an OVM.

This study was undertaken to develop a methodology to extract pesticides from the charcoal pad of an OVM as the first step in validating OVMs for monitoring of pesticide vapours in air.

Methodology. The charcoal pad was removed from an Organic Vapour Monitor and placed in a 13-mL centrifuge tube. A spiking solution was added consisting of either, 2,4-D, MCPA, triallate or trifluralin and triallate in a solvent. It was left overnight to allow the solvent time to evaporate. The herbicide was then extracted with carbon disulphide and diazomethane in ethyl ether. This extract could be analyzed directly for 2,4-D and MCPA on a gas chromatograph and mass spectrometer. For triallate and trifluralin the carbon disulphide and diazomethane in ethyl ether was evaporated and the herbicides reconstituted in hexane. These two herbicides were analyzed with a gas chromatograph using an electron capture detector.

Results and Discussion. Trifluralin, triallate, 2,4-D and MCPA were extracted from passive organic vapour monitors that use activated carbon as an adsorbent, with recovery rates ranging from 85% to 104% and detection limits of 1 µg/badge for the phenoxyacid herbicides and 0.1 µg/badge for trifluralin and triallate. Carbon disulphide was the best solvent to desorb trifluralin and triallate, although ethyl acetate and dichloromethane (95%)/methanol (5%) were also acceptable. Acetone gave recovery rates of 75% to 80% for trifluralin, but only 35% to 38 % recovery was obtained for triallate. Esterification of the phenoxyacetic acid herbicides, 2,4-D and MCPA, with carbon disulphide mixed 2:1 with diazomethane in ethyl ether was necessary before they could be extracted from the badges with acceptable recovery rates (99% and 101%, respectively). Dichloromethane, ethyl acetate or methanol mixed 5:1 with diazomethane in ethyl ether produced recovery rates for the phenoxyacid herbicides much lower than carbon disulphide mixed with diazomethane. The esterification

procedure did not affect the recovery rates for triallate and trifluralin, so all four herbicides could be extracted from a single badge using CS_2 and diazomethane. Recovery rates of 2,4-D, MCPA, trifluralin and triallate from passive 3M#3500 OVMs are as high as with active sampling systems using polyurethane foam as a collection medium.

This procedure is considerably easier than soxhlet extraction of other sampling media from flow-through air monitoring systems. The procedure may be made even easier, depending on the formulations of phenoxyacid herbicides collected on the OVMs. If 2,4-D and MCPA are collected in an ester formulation then the esterification process with diazomethane may not be necessary. This can be determined only through a field monitoring project, which is the next step in validating passive organic vapour monitors for pesticide vapour monitoring.

This work has been sent to a scientific journal for publication, citation of these results may be premature.

For more information, contact:

Miles Constable
Environmental Protection
Western and Northern Region
Environment Canada
4999 - 98 Ave.
Edmonton, Alberta
T6B 2X3

(403) 468-8038

PESTICIDES PROGRAM IN THE PACIFIC AND YUKON REGION

(British Columbia and Yukon Territory)

1. INVENTORY OF PESTICIDE USE IN THE YUKON, 1986 - (Rosanna C. White)

Introduction. This inventory of pesticide use was undertaken to obtain information on types, amounts and patterns of pesticide use in the Yukon. An additional objective was to identify priority needs for regulatory control of all phases of pesticide use, including transport, sales, storage, application, and disposal.

Methodology. The inventory was conducted by means of a mailed questionnaire, with follow-up by telephone and meetings. Retail and wholesale outlets, distributors, government departments and the agricultural community were contacted. Only data for 1986 pesticide use were obtained.

Results and Discussion. By volume of active ingredient, wood preservatives were the most-used pesticide product in the Yukon. Active ingredients included creosote, pentachlorophenol, zinc naphthenate, and copper naphthenate. The next greatest volume of use was for mosquito control insecticides, applied by the Yukon Government in several communities. Four products were used: Abate 2G (temephos) and Vecto Bac (*Bacillus thuringiensis*) as larvacides, and Malathion (malathion) and Prox 120 (propoxur) as adulticides. Common active ingredients of insecticides in domestic use were technical piperonyl butoxide, allethrin and dichlorvos. Agricultural herbicides were the third most important, with 2,4,-D being the most commonly used active ingredient, followed by MCPA-amine. Agricultural use was limited, with only two farmers applying significant quantities of herbicides. Other commonly found herbicide active ingredients for domestic use were mecoprop and dicamba.

Suppliers of pesticides were mainly located in Edmonton and Vancouver and all products were formulated outside of the territory. Pesticides were sold in general stores, department stores, gardening supply centres, drug stores, hardware stores, and grocery stores.

The report assessed the potential for the use of pesticides in the Yukon to present safety or environmental hazards. The level of use of pesticides in 1986 was low, but was considered to be likely to increase. The lack of any territorial legislation controlling pesticide use and the lack of public awareness of the dangers associated with pesticide use were pointed out. This has resulted in the uncontrolled sale of pesticides - products that are signable in B.C. (restricted for use with a variety of special conditions) were widely available on shelves of retail stores, and pesticides in some stores were located with the groceries. The need for public education and for better control of the use of pesticides in the territory was highlighted.

For more information, contact:

J. Eamer
Environmental Protection
Pacific and Yukon Region
101-204 Range Road
Whitehorse, Yukon
Y1A 3V1

(403) 667-3402

2. PESTICIDE DISTRIBUTION AND USE PATTERNS IN THE LOWER FRASER VALLEY

- (Anne Moody, Aim Ecological Consultants Ltd., Aldergrove, B.C.)

Introduction. The lower mainland of British Columbia is an important staging area for birds on the Pacific flyway and the lower Fraser River is a critical nursery area for juvenile salmon. The lower Fraser Valley comprises a large part of the agricultural land in the province and is subject to extensive use of agricultural chemicals. Pesticides used in this area may be carried by water into the local ditches and eventually enter the sensitive Fraser River estuary.

The purpose of this survey was to gain an appreciation of the type and quantity of pesticide use in this area of British Columbia to assist in the development of pesticide monitoring programs. (This project was supported by PESTFUND.)

Objectives. The objectives of the study were:

1). to identify the major existing retail outlets in the Fraser Valley;

2). to identify and quantify all pesticides sold in the lower Fraser Valley according to active ingredient and total product; and

3). to identify, for the various pesticides the crops protected, target species, types of application, and geographical areas of application.

Methodology. Information was gathered by questionnaire from pesticide retailers in the lower Fraser Valley of British Columbia. Information gathered from the questionnaire was then standardized and summarized to provide a perspective on regional pesticide use. Additional information on pesticide characteristics and toxicities was obtained from a variety of literature sources and government agencies.

Results and Discussion. The report provides lists of pesticides used in the lower Fraser Valley including product trade names, PCP Act No. active ingredients, and quantities sold during 1988. Pesticide sales are recorded according to locations in the Fraser Valley. Pesticide application rates are also provided.

The body of the report outlines the major pesticides used in the lower Fraser valley including trade names, formulations, application rates, target species, properties of the pesticides, crops protected, and miscellaneous uses.

Toxicity information for most of the pesticide active ingredients is provided for the rat and fish and wildlife species.

For more information, contact:

D.M. Wilson
Environmental Protection
Pacific and Yukon Region
3rd Floor, Kapilano 100
Park Royal South
West Vancouver, B.C.
V7T 1A2

(604) 666-3197

3. ABBOTSFORD OUTWASH AQUIFER PESTICIDE STUDY - (D. McNaughton)

Introduction. A sampling program of 21 wells conducted in 1985 by NHRI indicated that measurable quantities of the organochlorine compound 1,2-dichloropropane were detectable in wells and standpipes drilled into the Abbotsford Outwash Aquifer. The project described in the following was initiated as a follow-up to this work.

The primary objective of this project is to determine, through a groundwater sampling program in a permeable glacial outwash aquifer, what levels of various pesticides in use in the area are reaching the groundwater zone. The Abbotsford Outwash aquifer situated on the Canada-U.S. boundary represents a "worst case", in that it underlies an area of intensive agriculture, some irrigation is practiced, and annual precipitation is very high.

Methodology. This project has been essentially a survey. As yet, no intensive study has been dedicated to processes, or mechanisms. Water samples have been collected from various wells, and analyzed for parent compounds, or for the more common and recognizable breakdown products. More intensive work of this nature will be done upon the completion of the survey phase.

Results and Discussion. During 1988-89 Groundwater Division personnel conducted a drilling and sampling program in the Abbotsford Outwash Aquifer. The drilling program was conducted early in the 1988 fiscal year, and the sampling of the resulting observation wells was conducted in November, 1988. In addition to the sampling of observation wells installed by NHRI, wells which were installed by the British Columbia Department of Natural Resources were sampled. The samples collected were analyzed by a private laboratory (Chemex Ltd., of Calgary) in January, 1989.

Target compounds included the phenoxy-acid herbicides: 2,4-D, picloram, and dicamba; the carbamates: carbaryl, and carbofuran; organophosphate insecticides: dimethoate, diazinon, and guthion; the herbicides: dinoseb, and alachlor; organochlorine residues of DDT; and the organochlorine residue 1,2-DCP, which had been detected in 1985 and 1987 in groundwaters from beneath the area surrounding the Agassiz Research Substation, of Agriculture Canada. The analytical results showed very few positive detections for any of the pesticides analyzed. Out of the 18 samples submitted, there was one detection for alachlor (1.0 µg/L), two for atrazine (0.14, and 0.16 µg/L), one for carbofuran (0.5 µg/L), and six for 1,2-DCP. All other compounds fell below the applicable detection limit.

As yet, no regulatory, or other action is contemplated with respect to the results of this project. This must necessarily wait until all the evidence is in, and the project has been properly reported.

For more information, contact:

G. Grove
National Hydrology Research Institute
(NHRI)
11 Innovation Boulevard
Saskatoon, Saskatchewan
S7N 3H5

(306) 975-5735

4. SURVEY OF PESTICIDE CONTAMINATION OF GROUNDWATER IN HIGH RISK AQUIFERS, LOWER FRASER VALLEY - (Hugh Liebscher and Gordon Kan, Inland Waters, Vancouver, B.C.)

Introduction. Pesticide and nitrate contamination of groundwater is a recognized problem in selected aquifers in the Pacific and Yukon Region. Preliminary investigations by NHRI in the South Abbotsford area found localized detections (0 to 7.5 ppb) of the nematicide 1,2-dichloropropane. This earlier work, and nitrate investigations carried out by the province, precipitated this investigation to determine the existence of other pesticides in these aquifers.

Methodology. Fifty-one samples were collected from selected piezometers and water wells to determine the extent of groundwater pesticides and nitrate contamination in vulnerable agricultural areas in the Lower Fraser Valley. The majority of samples were taken from the Abbotsford Aquifer and the remaining samples were taken from unconfined aquifers in the Brookswood and Hopington areas.

Samples were analyzed by capillary gas chromatography, GC/MS with selected ion monitoring mode and high pressure liquid chromatography. The samples were also analyzed for enriched tritium and nitrates.

Results and Discussion. Results indicate that the major water quality issue of the Abbotsford aquifer appears to be excessive (0 to 41.5 mg/L) nitrate contamination. Twenty-nine of the 51 wells had nitrates exceeding the maximum allowable levels of 10 mg/L. Six of these wells exceeded 20 mg/L.

Traces of pesticides were detected in some of the wells. Results are being interpreted and will be available shortly.

Sources for nitrate contamination of groundwater appear to be from unprotected stock piling of manures on the sands and gravels through the winter months, excessive application of manures to berry crops, septic tank discharges, and fertilizer application.

Sources for pesticide contamination of groundwater appear to be chemical spillage around the well heads and downward percolation of pesticides with infiltrating rain and irrigation water.

Additional samples will be collected to determine seasonal fluctuations in those areas where pesticides and nitrates have been detected.

For more information, contact:

Hugh Liebscher
Regional Hydrogeologist
Environment Canada
Conservation and Protection
Inland Waters, Pacific & Yukon Region
502- 1001 West Pender Street
Vancouver, B.C.
V6E 2M9

(604) 666-0807

5. PRELIMINARY EVALUATION OF SELECTED PESTICIDES IN THE NICOMEKL WATERSHED, AND PROPOSED APPROACHES FOR ASSESSING TOXICITY TO AQUATIC BIOTA - (Stephen Sheehan and Fred Mah)

Introduction. A multi-year project to assess the potential toxic effects of agricultural pesticides on aquatic biota within the Lower Fraser Valley, B.C. was initiated in 1988. The project was divided into several phases, the first phase being completed in April 1989 by a contractor, Coastline Environmental Service Ltd.

The overall objective of Phase I was to develop a site-specific approach for predicting and monitoring the potential toxic effects on aquatic biota of pesticides entering a receiving water body by surface water runoff from farms and to select an area within the Fraser River Estuary Management Program (FREMP) for the toxic effects study.

Initially herbicides and insecticides registered in Canada and marketed to farmers in the Lower Fraser Valley were examined with respect to their use and hazard to the freshwater environment. Based on this appraisal, dinoseb and endosulfan were selected for investigation of their presence and potential toxicity to the aquatic life in the study area. The international scientific literature dealing with the freshwater fate and effect of these two pesticides was reviewed with emphasis on their toxic effects.

Methodology. Study sites were selected to confine the project to a portion of the Nicomekl River (a small river basin within the FREMP area) and adjacent agricultural drainage/irrigation ditches. These ditches discharge seasonal runoff from adjoining farms directly to the Nicomekl River. Available information regarding sources of Wastewater discharges to the Nicomekl River and its tributaries was reviewed together with data on river water quality and water uses. The irrigation/drainage ditch configurations and flow control devices were described.

In March 1989, samples of water and sediment were collected from various sites along the Nicomekl River and from certain ditches near their confluence with the river. These samples were analyzed for dinoseb and endosulfan using solvent extraction followed by Florisil column chromatography and electron capture gas chromatography. All river and ditch water samples showed concentrations below the detection limit for both endosulfan and dinoseb. Concentrations of dinoseb in sediment ranged from undetectable to 49 µg/kg. With the exception of one ditch sample containing 428 µg/kg, endosulfan concentrations in sediment ranged from undetectable to trace levels. The relevance of these findings was discussed with respect to the study area, published findings, available water quality criteria for these pesticides and the known water quality of the Nicomekl River.

Results and Discussion. Based on the foregoing, an approach for future site-specific toxicity assessments of the study area was presented. Biological testing of selected ditch and river water samples including a series of acute lethal/sublethal toxicity tests to determine effect/no effect concentrations was recommended. Chronic toxicity tests using Ceriodaphnia and fathead minnows as well as algal toxicity tests were also recommended. Field toxicity tests and surveys for biological effects were proposed for future study. Chemical analyses for pesticides and other contaminants of toxic test waters were integrated in the design. The proposed approach included suggested sampling stations and frequencies of monitoring.

For more information, contact:

Stephen Sheehan
502-1001 West Pender Street
Vancouver, B.C.
V6E 2M9
(604) 666-8007

6. DISTRIBUTION AND PERSISTENCE OF DIAZINON IN A CRANBERRY BOG - (M.T. Wan - Environmental Protection, and S. Szeto et al., Agriculture Canada)

Introduction. Diazinon [0,0-diethyl 0-(2-isopropyl-6-methyl-4-pyrimidinyl) phosphorothioate] is an organophosphate insecticide which offers the potential to control the cranberry girdler moth *(Chrysoperichia popiariae)*in the cranberry bogs of British Columbia. A pre-registration field trial was undertaken in 1988 to evaluate the efficacy of this pesticide for the control of the girdler moth. Concerns were raised about the possible effects of diazinon on juvenile anadromous salmonids, as this insecticide is known to be highly toxic to fish.

The objective of this study was to monitor the persistence of diazinon in the sediments and water within and outside the treated fields.

Methodology. Diazinon 5G was aerially applied twice at two weeks apart to a 19-ha cranberry bog at the rate of 6 kg/ha. Water and sediment samples were taken within and outside the treatment plot at regular intervals to determine the levels of diazinon and its main metabolite diazoxon.

Results and Discussion. Pre-spray water and sediment samples from six sampling stations contained no detectable (detection limits: 0.1 µg/L, water; 10 µg/L, sediment) residues of diazinon. Within the treated plot, the level of diazinon twenty-four hours after treatment was 338 and 456 µg/L after the first and second aplication, respectively, in the irrigation ditches. The concentrations decreased to below 100 µg/L within three to four days after each application, and to 8.3 µg/L four weeks after the first treatment. Diazinon was no longer detected in the irrigation ditches 42 days after the first application.

Similar trends were observed in water from reservoir canals outside the treatment plot and the receiving tributaries 100 m downstream, but at much lower concentration. The highest residues were 78.5 µg/L in the reservoir adjacent to the treatment plot, 29.1 µg/L in the waterways outside the dyke, and 2.8 µg/L in the tributaries about 100 m downstream from the edge of the treatment plot. The minute amounts of diazinon (2.8 µg/L max.) that persisted for four to five days in the tributaries about 100 m downstream from the edge of the treatment plot were thirty-two times below the 96-h LC_{50} of rainbow trout, and should have a minimal effect on fish.

The level of diazinon in sediments from the irrigation ditches inside the treatment plot was 21.2 mg/kg (wet wt.) four days after the first aplication and 8.92 mg/kg three days after the second application. Diazinon was detected in the sediments for 4.5 months but at a much reduced concentration, (i.e., at 0.02 mg/kg). The highest concentration found in the sediment from the waterways outside the cranberry plot was 0.08 mg/kg one day after application. Diazinon was detected only once in sediments from the tributaries 100 m downstream at 0.01 mg/kg four days after the first application. These results demonstrated that little transport of diazinon occurred from the treatment plot to its surrounding waterbodies.

Results and Discussion. When applied twice at the rate of 6 kg a.i./ha by fixed-wing aircraft on a British Columbia cranberry bog, diazinon 5G persisted in the water and sediments of the treated plot for at least 5 and 19 weeks, respectively. Despite the use of gates to control the discharge of water out of the cranberry field, diazinon residues were found in both the water and sediments of the receiving tributaries 100 m downstream, but at a much diluted concentration, ranging from 0.1 to 2.8 µg/L for about five weeks in water and 0.01 mg/kg for one day in sediments.

For more information, contact:

M.T. Wan
Environmental Protection
Pacific Region
3rd Floor, Kapilano 100
Park Royal South
West Vancouver, B.C.
V7T 1A2

(604) 666-3111

7. THE EFFECTS OF DIFFERENT DILUTION WATER TYPES ON THE ACUTE TOXICITY OF GLYPHOSATE AND ITS FORMULATED PRODUCTS TO JUVENILE PACIFIC SALMONIDS AND RAINBOW TROUT - (M.T. Wan et al.)

Introduction. Glyphosate [N-(phosphonomethyl) glycine] is a broad spectrum herbicide manufactured by the Monsanto Company. Its formulated product Roundup^{R}, also known as Vision^{R}, in Canada, is a non-selective herbicide. Concerns have been raised about the applicability of the 96-h LC_{50} data to natural water for young salmon of Roundup^{R} assayed in reconstituted water.

The objective of this study was to compare the effects of reconstituted water and four natural sources of dilution water on the acute toxicity to juvenile Pacific salmonids and rainbow trout of glyphosate and its formulated products: Roundup^{R}, MON 8709, and their surfactant MON 0818.

Methodology. A series of 96-h static acute toxicity tests was conducted using five species of juvenile salmonids (coho, chum, chinook, and pink salmon, and rainbow trout) obtained in fresh water from British Columbia hatcheries. The tests were carried out from February to June 1988 in accordance with established protocols and procedures. Testing was undertaken at a temperature of 14 ± 1°C, and with a 16-h light:8-h dark photoperiod regime. The average loading density was 0.25 (0.10 to 0.4 g/L), and the test volume was 20 L. Ten fish were placed in each test vessel. The cumulative fish mortality was recorded and the LC_{50} values were calculated using the "Lethal" computer program.

Five different sources of water were used as dilution water:

1). city tap (Vancouver dechlorinated);

2). creek (Chehalis Creek, British Columbia);

3). reconstituted deionized city tap [$CaSO_4{\cdot}2H_2O$, KCl, $MgSO_4$, and $NaHCO_3$ (APHA, 1985)];

4). well (Cypress Well, British Columbia, Canada); and

5). lake (Cultus Lake, British Columbia).

Results and Discussion. Glyphosate is significantly more toxic to juvenile salmonids in soft (city, creek) water than reconstituted water. This chemical is also significantly more toxic to fish in reconstituted water than in hard (lake) water. However, it is equally toxic to salmonids in similar (well) water type. MON 0818 toxicity to salmonids in reconstituted water is not significantly different to test results of the other water types.

Of the formulated products, MON 8709 is significantly more toxic to salmonids in reconstituted water than soft (city, creek) water but not in similar (well) water and hard (lake) water types. Roundup^{R} toxicity to salmonids (96-h LC_{50} 20 mg Roundup^{R}/L) in reconstituted water is not significantly different to test results of the other water types. Tests of Roundup^{R} in a soft, slightly acidic water yield the upper range of the 96-h LC_{50} value (30 mg Roundup^{R}/L), while test results from a hard and slightly alkaline pH water produce the lower range (14 mg Roundup^{R}/L).

The surfactant MON 0818 is the most potent toxicant to salmonids when compared to glyphosate, MON 8709, and Roundup^{R}, irrespective of water types. Glyphosate by itself is most toxic to salmonids in soft water and least toxic (12 times less) to the fish in hard water. MON 0818 is most toxic to salmonids in hard water. In the formulated products, both MON 8709 and Roundup^{R} are significantly more toxic to salmonids in hard water than they are in soft water, with Roundup^{R} almost twice as lethal as MON 8709. Roundup^{R} contains 50% more MON 0818 surfactant than MON 8709. As well, MON 0818, MON 8709, and Roundup^{R} are significantly more toxic (twice as toxic) to salmonids in hard water than they are in soft water.

Conclusions. This study indicates that a notable variation of 96-h LC_{50} values is attained for the

same fish species when different water types are used in the bioassay of glyphosate, MON 0818, MON 8709, and Roundup^{R}. Variation of 96-h LC_{50} values for MON 0818, MON 8709, and Roundup^{R} is in the same order of magnitude, irrespective of water types. For glyphosate, the 96-h LC_{50} values for different water types can vary by an order of magnitude. Hardness of water and pH appear to be the key factors causing the variation of 96-h LC_{50} values. Roundup^{R}, MON 8709, and MON 0818 are more toxic to young salmonids in hard than they are in soft water, while the reverse holds for glyphosate. Salmonid 96-h LC_{50} data for Roundup^{R} and MON 0818, **but not** for glyphosate and MON 8709, obtained from reconstituted water (APHA, 1985) are generally similar to 96-h LC_{50} values generated from natural sources of dilution water.

For more information, contact:

M.T. Wan
Environmental Protection
Pacific and Yukon Region
3rd Floor, Kapilano 100
Park Royal South
West Vancouver, B.C.
V7T 1A2

(604) 666-3111

PESTICIDES PROGRAM AT THE NATIONAL WILDLIFE RESEARCH CENTRE (NWRC) HULL, QUEBEC

1. DEVELOPMENT OF GUIDELINES FOR TESTING PESTICIDE TOXICITY TO NONTARGET PLANTS - (Dr. Kathryn Freemark, Canadian Wildlife Service); Patricia MacQuarrie, Commercial Chemicals Branch))

Introduction. Environment Canada is concerned about the potential hazards posed to nontarget organisms and their habitats from exposure to pesticides during application, accidental overspray, spray drift, runoff, or leaching. In particular, protection of plants other than agronomic species such as crops, ornamentals etc., is not adequately and systematically considered during the process of pesticide registration in Canada. This project continued the work started in 1987-88 to develop Canadian guidelines for testing pesticide toxicity to nontarget plants.

In consultation with an Interdepartmental Working Committee (involving Environment Canada, Agriculture Canada, Fisheries and Oceans Canada and Forestry Canada), the objective is to continue development of guidelines for testing pesticide toxicity to nontarget plants.

Methodology. A combination of contract and in-house work was used to continue this project.

Results and Discussion. The contract report in which the Saskatchewan Research Council (SRC) reviewed existing international requirements for pesticide toxicity to nontarget plants, evaluated problems with current regulatory guidelines and tests used, identified knowledge gaps in phytotoxicity testing, and provided conclusions and recommendations for developing guidelines for Canada, was reviewed in consultation with the interdepartmental Phytotoxicity Committee. The report was edited and distributed to 200 people for peer review. Publication as an Environment Canada report is in progress.

A contract report on aquatic plant test species was submitted by the Saskatchewan Research Council and is currently under review.

In collaboration with the Environmental Protection Laboratory in Longueuil, Quebec, a contract was let to develop algal microplate testing techniques for pesticides. The contract is still in progress.

An in-house project was initiated to develop a background document on plant-mediated effects on wildlife related to pesticide use by reviewing the scientific literature. Review and publication of the report is planned for the coming year.

An abstract was accepted for the first American Society for Testing and Materials Symposium on "Use of Plants for Toxicity Assessment" in April, 1989. The Symposium should provide a forum for interested scientists in academia, governments and industries, to share ideas, stimulate research, and provide a consensus for better practices and standards. A paper being prepared for the ASTM symposium and the related Special Technical Publication. A draft was presented as a poster at the 9th Annual Meeting of the Society of Environmental Toxicology & Chemistry, Nov. 13-17, 1988, at Arlington, VA.

Project activities were outlined in the Note series of the Canadian Association of Pesticide Control Officials (CAPCO Note 89-10).

This project is providing important background documents, and a consultative mechanism for identifying regulatory needs and potential areas of future research, and for discussing and drafting guidelines for testing pesticide toxicity to nontarget plants for Canada.

For more information, contact:

Dr. Kathryn Freemark
Canadian Wildlife Service
National Wildlife Research Centre
Environment Canada
Ottawa, Ontario
K1A 0H3

(819) 997-6082

Patricia MacQuarrie
Commercial Chemicals Branch
Environment Canada
Ottawa, Ontario
K1A 0H3

(819) 953-1681

2. DEVELOPMENT OF DATA BASES ON BIRD USE OF AGRICULTURAL HABITATS -

(Dr. Kathryn Freemark, Canadian Wildlife Service, National Wildlife Research Centre, Ottawa); Dr. C. Weseloh, Canadian Wildlife Service, Ontario Region, Burlington)

Introduction. In order to identify and interpret the ecotoxicological significance of pesticides effects on Canadian wildlife and provide advice and recommendations to prevent or mitigate these effects, data bases on wildlife use of habitats potentially exposed to agricultural pesticides are needed for Canada. This project continues work initiated in 1987-88.

The objective of this project was to generate information on bird use of agricultural habitats in Canada for use in evaluating potential hazards posed by pesticide use.

Methodology. Data were compiled from reviews of the scientific literature and field surveys conducted under contract.

Results and Discussion. Wildlife use of habitats in agricultural landscapes in the Great Lakes-St. Lawrence region was examined using the scientific literature. An existing database developed by identifying habitats and abstracting data on bird use by species, activity, time of year and intensity of use was updated and expanded under contract. A manuscript was prepared which:

1). assembled the bird use data by habitat type;

2). presented crop area data which can be coupled with bird use data to quantify the potential risk posed by use of agricultural pesticides;

3). identified future research needs; and

4). provided an annotated bibliography.

The manuscript is to be published as a CWS Technical Report in the coming year.

Because of the lack of information for most croplands in this region, field work initiated under contract in 1987 to document bird use of selected crops in south-western Ontario (joint project with CWS-Ontario Region) was continued. Bird species use for each crop has been compiled under contract by year, month, mean abundance, within and among field variance, and activity (e.g., feeding, foraging, etc.). Further analyses and project documentation are in progress.

Other field studies, such as the Agricultural Bird Census pilot project in Saskatchewan (joint project with CWS-Western & Northern Region) have also been conducted. Analyses are planned for the coming year to tabulate bird species composition and abundance by habitat type, and to examine the importance of proximal habitat on avian use patterns.

For more information, contact:

Dr. Kathryn Freemark
Canadian Wildlife Service
National Wildlife Research Centre
Ottawa, Ontario
K1A 0H3

(819) 997-6082

3. AGRICULTURAL BIRD CENSUS (ABC) IN CANADA - (Dr. Kathryn Freemark, Canadian Wildlife Service, National Wildlife Research Centre, Ottawa; and Dr. Anthony Diamond, Canadian Wildlife Service, Western & Northern Region, Saskatoon)

Introduction. As part of Environment Canada, the Canadian Wildlife Service is responsible for identifying and interpreting the ecotoxicological significance of pesticide use (both current and future) on Canadian wildlife (particularly migratory birds) and their habitat, and for providing advice and recommendations to prevent or mitigate effects. At present, no program exists in Canada which provides adequate data on birds potentially exposed to pesticides in agricultural landscapes.

The ABC project was undertaken to investigate the feasibility of establishing an Agricultural Bird Census (ABC) in Canada as a means of providing data for:

i). assessing potential effects on wildlife and their habitats from proposed uses of pesticides;

ii). monitoring changes in spatial distributions of species and/or in population structure or numbers in order to evaluate the effects of pesticides and other stress factors on the overall health of bird populations; and

iii). assessing effects on wildlife and their habitats from use of specific pesticides.

The project focussed on birds in agricultural habitats in Saskatchewan.

Methodology. Using PESTFUND support, contracts were developed and let to design, in consultation with the project leaders, bird census and habitat sampling protocols, to conduct the field work, to computerize and document the data, and to compare the different censusing techniques. In-house analyses are in progress to examine potential sampling biases in the field data, to document bird species composition and abundance by habitat type, to investigate the importance of proximal habitats on avian use patterns, and to further compare the census methods used.

Results and Discussion. Breeding birds on 33 quarter sections of cropland were censured by two methods and the data computerized. The habitat on those quarter sections was mapped and computerized. A contract report was submitted on the field procedures, databases, and logistics for conducting a pilot ABC in Saskatchewan. A contract report comparing the census techniques used was submitted and will be critically reviewed in the coming year. In-house analyses are in progress.

The results will provide useful data for assessing potential risk to birds from use of agricultural pesticides in the prairies, and for assessing the future of an ABC in Canada.

For more information, contact:

Dr. Kathryn Freemark
Canadian Wildlife Service
National Wildlife Research Centre
Ottawa, Ontario
K1A 0H3

(819) 997-6082

4. RISK TO THREATENED AND ENDANGERED SPECIES FROM PESTICIDE USE - (Karen Lloyd, Canadian Wildlife Service)

Introduction. Protection of threatened and endangered species from pesticide use in Canada has not been systematically considered during the process of pesticide registration. Many of these species occur in areas where pesticides are used, and therefore are potentially at risk due to either direct toxicity of the pesticide or its modifying effects on critical habitat. This year was the second year of a multiyear study in developing methods for assessing risk to endangered species.

The objectives of this study were:

1. to identify the threatened and endangered species whose habitats overlap with areas of pesticide use;

2. to identify and rank those pesticides and pesticide use patterns that may place a threatened and endangered species at risk; and

3. to identify research and monitoring needs and other strategies to reduce these risks.

Methodology

1. Data were collected on the distribution and biology for all species designated by the Committee on the Status of Endangered Wildlife in Canada as threatened or endangered. Distribution data were mapped using the geographic information system SPANS. Data on the biology of each species were entered on DBase.

2. Distribution of 86 crops were obtained from the Statistics Canada 1986 Census of Agriculture and were also mapped on SPANS. This information acts as a surrogate for potential areas of use for new pesticides.

3. SPANS was used to overlay maps of distribution of species and crops to determine potential areas of overlap, and hence potential exposure.

Results and Discussion. Maps are now available on all species and on the 86 crops on the data base. This method has proven to be useful as a rapid screening tool in the risk assessment process. For those species with large geographical ranges (many birds and large mammals), these databases are of limited use. For these species more detailed information on habitat types is required.

For more information, contact:

Karen Lloyd
Canadian Wildlife Service
National Wildlife Research Centre
Environment Canada
Ottawa, Ontario
K1A 0H3

(819) 997-6073

5. THE SECONDARY HAZARD OF RID-A-BIRD PERCHES TO FALCONS - (K. Hunt and D. Bird, Raptor Research Centre, Ste-Anne de Bellevue, Quebec; P. Mineau, National Wildlife Research Centre, Hull, Quebec)

Introduction. Kills of raptors have been recorded following the use of toxic "rid-a-bird" perches intended for the control of starlings, blackbirds and pigeons. The company which markets this product contends that the kills were a result of misuse. Fenthion is extremely toxic to birds and secondary poisoning is theoretically possible. Urban areas are increasingly used as release sites for captive-bred Peregrine Falcons. The heaviest use of "rid-a-bird" perches is probably in cities for the control of pigeons.

Objectives. To test the secondary toxicity potential of "rid-a-bird" perches to birds of prey under realistic conditions and to assess whether intoxicated prey (following contact with the perches) are more vulnerable to be taken by avian predators.

Methodology. American kestrels and house sparrows were used in a model predator/prey relationship. Kestrels were presented with sparrows which had been exposed to the toxic perches for a five-minute period. (Sparrows had been tested on the perches for differing amounts of time - five minutes was chosen as a compromise between the extent of exposure and the time to death of the target sparrows.) Kestrels were observed while they captured and consumed their prey in an indoor aviary.

For the second objective, kestrels were allowed to hunt flocks of sparrows comprising three undosed and one dosed bird to determine the relative vulnerability of dosed and undosed sparrows.

Results and Discussion. Of 14 exposure trials, 11 Kestrels died within a 21-h period after killing and consuming from 18% to 80% of only one sparrow. Brain samples analyzed from these kestrels showed an average of 82% cholinesterase inhibition. Plasma samples drawn within a 4-h period after consumption showed a mean inhibition of 96%. It appears that the risk of secondary poisoning is quite high at least under conditions of exposure tested here.

In the second experiment, kestrels selected the dosed bird from the flock of four on 12 of 15 trials. Under these conditions, the relative vulnerability of the exposed sparrows was calculated to be 12 times that of the unexposed sparrows. This therefore confirmed our fears that exposed "target" birds are more vulnerable to predation.

Residue analyses were conducted on sparrow body parts as well as on the gastrointestinal tracts of the kestrels.

The results of this work are being prepared for publication. It is also expected that these results will weigh heavily in the re-evaluation of the safety of fenthion-containing "rid-a-bird" perches to wildlife.

For more information, contact:

Pierre Mineau
Head of Pesticide Evaluation
Canadian Wildlife Service
National Wildlife Research Centre
Ottawa, Ontario
K1A 0H3

(819) 997-3045

6. FURTHER STUDIES ON THE IMPACT OF AGRICULTURAL PEST CONTROL PRACTICES ON THE BURROWING OWL, A THREATENED SPECIES - (Glen Fox, Canadian Wildlife Service)

Introduction. Many farmers in the prairie provinces use strychnine for gopher control. Because gophers inhabitat the same areas as Burrowing Owls, strychnine may pose a risk to Burrowing Owls.

Methodology. Strychnine-coated grain was placed in 2900 burrows on eight pastures where 27 pair of owls were nesting. The owl burrows were monitored for 48 hours prior to application of the poisoned bait and for 48 hours following the application.

Results and Discussion. Gophers were effectively controlled by this procedure. There were no changes in owl numbers. Owls scratched the bait out of their burrow entrances, and when presented with poisoned gophers, they showed no interest in them. Strychnine is not believed to pose a risk to Burrowing Owls.

For more information, contact:

Glen Fox
Canadian Wildlife Service
National Wildlife Research Centre
Environment Canada
Ottawa, Ontario
K1A 0H3

(819) 997-6076

7. SOIL INCORPORATION OF CEREAL SEED AND GRANULAR INSECTICIDES USED DURING CANOLA SEEDING OPERATIONS - (R.P. Atkins and R.C. Maze, Alberta Farm Machinery Institute, Lethbridge, Alberta; P. Mineau, National Wildlife Research Centre, Hull, Quebec)

Introduction. Granular formulations of insecticides are widely used in Canada, often over very large acreages. One application of concern which has been identified is the prophylactic use of granulars applied to canola (rapeseed) at seeding (Mineau, 1988). It takes place over a broad zone of the western prairies and parklands at a time when large flocks of arctic migrants are passing through on their way to nesting grounds. Granules have proven to be attractive to birds and their toxicity is such that a single granule may exceed the lethal dose. A key question, therefore, is the extent to which they remain on the soil surface following application. One large kill of Lapland Longspurs has already been recorded. The company which manufactures carbofuran, the product which caused the kill, claims that it was a case of misuse.

Similarly, unincorporated seed constitutes a prime exposure route for a number of bird and mammal species. Large kills of wildlife were recorded historically with organochlorine and mercurial seed coatings. Very little information exists on incorporation rates of seed under typical prairie agricultural conditions.

The objectives of this study were to measure the amount of unincorporated granules following canola seeding operations with representative machinery and seeding conditions and the amount of unincorporated seed during cereal seeding operations.

Methodology. Four different types of seeding equipment were tested under both ideal and no-till conditions. Seeds and granules were treated with a fluorescent dye and photographs used to assess the number of seeds or granules remaining on the soil surface. Wheat was the test cereal and the granule was modelled after carbofuran granules.

Results and Discussion. Results from this work are being prepared for publication. Counts of wheat seeds left on the soil surface ranged from 0.1% to almost 3% of applied material depending on the equipment and soil type. Granule counts ranged from less than 1% to almost 7%. These last figures are of concern because of the potentially large number of granules available to birds. Furthermore, the results suggest that the most commonly used type of canola seeding equipment, and the one recommended by the granule manufacturer, results in the poorest incorporation of granules.

These results will be important in the hazard evaluation of granular products in general, and of carbofuran in particular. Carbofuran (both in liquid and granular forms) is currently under regulatory re-evaluation because of the hazards to wildlife and the large number of documented kills (cf. Burrowing Owl project).

Reference

Mineau, P., "Avian Mortality in Agroecosystems. 1. The Case Against Granular Insecticides in Canada," In : Environmental Effects of Pesticides, British Crop Protection Council Monograph No. 40, pp. 3-12 (1988).

For more information, contact:

Pierre Mineau
Head of Pesticide Evaluation
Canadian Wildlife Service
National Wildlife Research Centre
Ottawa, Ontario
K1A 0H3

(819) 997-3045

8. EVALUATION OF THE USEFULNESS OF AVIAN REPRODUCTION STUDIES AS CURRENTLY DESIGNED - (D.C. Boersma, P. Mineau, B. Collins, and D. MacLeod, National Wildlife Research Centre, Hull, Quebec)

Introduction. This is the second year of a three-year project to determine the current validity of the avian reproduction test and to determine whether it is adequate, should be modified, or even eliminated. Results from the first year indicated a lack of comparability between studies, due in large part to the different statistical methodologies which were utilized. Raw data could not be obtained for all the studies. Hence there are two phases of statistical work now in progress.

The objectives of this year's work were to work with the studies summarized since the project's inception and to determine the following:

1) which studies showed an effect using the same analysis for all studies;

2) how to define the effects as maternal toxicity or reproductive toxicity;

3) whether dosage rates correspond to recent useage rates for the compounds under study using median, realistic but not necessarily worst-case values; and

4) what statistical methodology has been used in similar studies, both mammalian and avian, and to determine, for the avian reproduction studies, the validity of some of the methods used in the past.

Methodology. The first two objectives required close cooperation with statisticians. Two data bases were set up, one of historical control data, and another of treatment data as a ratio of control. Various statistical methodologies were run on these data bases. A literature search was done on statistical methodologies and a report written. A literature search was also done on reproductive studies of similar nature.

Results and Discussion. By using principal component analysis and variable clustering the data were summarized into three groupings, presently defined as parental toxicity, eggshell effects and reproductive toxicity. Work on the historical control data is now in progress, with the intent of investigating study design and sensitivity. The second draft of the report on the validity of statistical methodologies used in avian reproduction studies will soon be completed.

Usage rates have been obtained for all the compounds used, and the studies have been rated as to whether the dose levels were lower than or similar to/ higher than those expected in the environment. Studies in the former category that show an effect are of concern. Work on all aspects is on-going.

For more information, contact:

P. Mineau or D. Boersma
Canadian Wildlife Service
National Wildlife Research Centre
Ottawa, Ontario
K1A 0H3

(819) 997-3045

Appendix

Environment Canada's Input into Decision Documents

Agriculture Canada has issued a series of documents to provide information on new developments on pesticide regulatory issues: CAPCO Notes, New Product Notes, Discussion Documents, and Decision Documents. CAPCO Notes and New Product Notes provide an informal update of the regulatory status of products or a brief summary on the uses of a new product. Discussion and Decision Documents provide a summary of the scientific data on a product, outline the rationale for any regulatory action, discuss the options available, and solicit comments and feedback on difficult regulatory decisions.

These documents also describe special situations that can arise as a result of a need to register a new pesticide active ingredient or a new use with data gaps or special concerns.

Input into Decision Documents is provided by Agriculture Canada and its core advisors: Health and Welfare Canada, Fisheries and Oceans Canada, and Environment Canada. The following is the input by Environment Canada (Environmental Protection and the Canadian Wildlife Service) into the Decision Document (89-03) for clofentezine, a miticide.

CLOFENTEZINE

Environmental Chemistry and Fate

The following review and evaluation by Environment Canada (Conservation and Protection, Canadian Wildlife Service) was based on the proposed use pattern on apples.

Physicochemical Properties. The vapour pressure at 25°C was extrapolated using Clapeyron-Clausius analysis and found to be 1.3×10^{-7} Pa. This result indicates that clofentezine is unlikely to dissipate in the environment by volatilization.

The octanol/water partition coefficient for clofentezine was reported to be 1353 (log K_{ow} = 3.1). The accuracy of this value is questionable since it was based on measured concentrations of clofentezine in the aqueous phase which were well above the solubility limit in water.

Clofentezine was found to be essentially insoluble in water. The results of various determinations indicated that the solubility of clofentezine in water is<40 ppb.

Transformation. Clofentezine will undergo base-catalyzed hydrolysis. The half-lives for hydrolysis were reported to be approximately 4 hours at pH 9, 34 hours at pH 7 and 249 hours (10 days) at pH 5. Because of various difficulties in conducting hydrolysis studies due to the low water solubility, the accuracy of these half-lives is uncertain. However, it can be concluded from all the evidence provided that hydrolysis of clofentezine occurs fairly rapidly at environmentally relevant pH's.

Phototransformation studies indicated that clofentezine can undergo phototransformation quite readily in water, but is relatively stable to light on a soil surface.

Biotransformation studies showed that clofentezine residues will dissipate in soil by binding, by biotransformation and, most probably, by hydrolysis. Under aerobic soil conditions in the laboratory, the DT_{50} for clofentezine ranged from 4 to 8 weeks at 22°C and 9 to 14 weeks at 15°C. Under anaerobic conditions (flooded soil), clofentezine appeared to be more readily bound to soil and less readily transformed than under aerobic conditions. Mineralization of clofentezine residues to CO_2 proceeded rapidly in aerobic soils, but ceased when soils were flooded. Studies with sterilized soils indicated that complete mineralization of clofentezine residues required full microbial activity and that non-biotic processes (e.g., hydrolysis) may be important in the transformation of clofentezine in soil. Studies conducted in the laboratory with freshly collected sediment/water samples indicated that clofentezine will partition readily into sediments and will be readily transformed. The DT_{50}'s of extractable clofentezine residues from both sediment and water in these samples were <7 days.

In biotransformation studies no transformation products were observed that were both major and persistent. However, in aqueous phototransformation studies conducted under sterile conditions, the transformation product, 2-chlorobenzonitrile, was observed to accumulate, accounting for 75% of the recovered radioactivity by the end of a 31-day sunlight exposure period. In dark controls, this transformation product also accumulated over the study period, but accounted for a maximum concentration of only 6% by the end of the study. On a soil surface treated with ^{14}C-clofentezine, 2-chlorobenzonitrile accounted for 5.5% of the applied radioactivity after exposure sunlight over a period of 31 days. In hydrolysis studies, 2-chlorobenzonitrile was observed in samples taken at approximately 1.5 half-lives for clofentezine hydrolysis and accounted for approximately 6% of the recovered radioactivity. In non-sterile, aerobic soil samples and in sediment/water microcosms incubated in the dark, 2-chlorobenzonitrile was not observed, which may indicate that the compound is rapidly biodegraded, strongly adsorbed, or formed only in undetectable quantities.

Further information was provided to show the probable fate of 2-chlorobenzonitrile in the environment. The transformation of similar compounds, bromoxynil and dichlobenil, in which nitrite groups are hydrolyzed to corresponding amides and then further hydrolyzed to the acid and then CO_2, suggests a similar route for 2-chlorobenzonitrile. Because of (1) the low

potential for mobility of clofentezine; (2) the potential for 2-chlorobenzonitrile to hydrolyze; and, (3) 2-chlorobenzonitrile was not observed in soil, further studies are not required at this time.

Environmental Dissipation. Under field conditions in both Canada and the United Kingdom, clofentezine was seen to be non-persistent to moderately persistent in soil, with DT_{50}'s ranging between 19 and 73 days. In soil surface litter in a B.C. orchard, clofentezine appeared to be non-persistent following an early season application. However, some additional information concerning experimental design was necessary to substantiate these observations and to define the scope of the submitted information.

The results indicate the clofentezine should dissipate fairly rapidly in orchard litter following the proposed single early-season applications.

The results of both laboratory and field studies indicated that clofentezine will not leach through soil.

Environmental Toxicology

The submitted studies indicated that clofentezine is of low toxicity to earthworms, soil microorganisms, honey bees, and indicator species of fish and aquatic invertebrates. Clofentezine was stimulatory to algae at low concentrations, possibly by acting as a source of nitrogen. No algal growth inhibition was observed.

The bioconcentration factor for clofentezine in bluegill sunfish was reported to be 430. The depuration of residues from the fish was rapid with 88% being eliminated after three days from the cessation of exposure.

The submitted information indicated that clofentezine would not be directly toxic to the following beneficial predators and parasites, some of which are important in integrated pest management in orchards: *Typhlodromus occidentalis, Phytoseiulus persimilis.* The safety of clofentezine to *Typhlodromus pyri* was also shown; however, there was some evidence which suggested a low level of mortality in eggs and nymphs of this predator for seven days after being sprayed with solution containing 300 ppm clofentezine under field conditions.

Wild Birds. The acute toxicity of clofentezine to birds is low. No mortalities occurred when adult bobwhite quail were given an oral dose of 7500 mg active ingredient/kg body weight. Exposure of birds in orchards through ingestion of food contaminated with clofentezine is also unlikely to cause mortality. When fed levels of up to 20 000 mg clofentezine/kg diet for five days, there was no mortality among 10-day-old bobwhite quail, and 10-day-old mallard ducks.

Clofentezine is reported to be a highly effective bird repellent at 10 to 1000 g/ha. This level is considerably below that being acutely toxic to birds, and should provide an additional margin of safety (MOS) to avian species. However, no data are available to support this.

Effects on avian reproduction have not been studied, nor have any field studies on birds been done. Given the very low acute toxicity of clofentezine to birds, and its rapid metabolism, the need for avian reproduction studies and major field assessment of effects on birds seems unwarranted.

Wild Mammals. Clofentezine technical is not highly toxic to laboratory rats, mice, hamsters, guinea pigs, or dogs. Acute oral LD_{50} values range from 1500 mg a.i./kg for the guinea pig to 3200 mg a.i./kg for the rat, mouse, and hamster. Similarly, the formulated product, Apollo SC, is also of low toxicity, the acute oral LD_{50} for the rat being greater than 2100 mg a.i./kg.

Using the technical product, the acute intraperitoneal LD_{50} for the rat is 800 mg a.i./kg.

A stable aerosol of Apollo SC could not be made, thus inhalational toxicity was not calculated for the formulated product. Inhalation of the formulated product is not expected to be a major route of exposure to wildlife.

Studies on the metabolism of clofentezine have shown that it is extensively metabolized and rapidly eliminated by rats, rabbits, dogs, mice and baboons. Clearance is almost complete within two days.

No field studies on wild mammals have been done. Mammals could be exposed either dermally or through their food. At levels of exposure expected following application of Apollo SC to apple orchards, wild mammals should be at little risk, and field studies are not justified at this time.

Amphibians and Reptiles. No data are available to evaluate the risk to amphibians and reptiles.

Aquatic Invertebrates. Due to the low solubility of technical clofentezine (i.e., 35 µg/L), difficulties were encountered in obtaining LC_{50} values in aquatic toxicity studies. In a study using *Daphnia magna*, 100 mg a.i./L were added to the test vessel, but the clofentezine remained in suspension; the actual dissolved concentration was less than 0.14 mg a.i./L. At this concentration, mortalities did not exceed those of the control. A study using the more soluble, formulated product, Apollo SC, however, showed that there were no toxic effects, measured as immobilization, on *Daphnia magna* at concentrations as high as 100 mg a.i./L. The concentration of the test solution decreased by 50% during the 48 hour duration of the test due to hydrolysis; however, concentrations still far exceeded that which would occur assuming a direct overspray of a shallow body of water (i.e., 0.05 mg a.i./L).

Terrestrial Invertebrates. The formulated product (50% WP) is of low toxicity to worker honey bees, *Apis mellifera*. The contact LD_{50} was greater than 1500 mg a.i./L, and the oral LD_{50} was greater than 20 µg/bee.

One and six months after a field application of 372 g a.i./ha of the 50% WP, no effect on numbers of earthworms was detected.

When clofentezine technical was applied at 1.0 and 10.0 kg a.i./ha, no effect on ammonification was observed on either sandy loam or clay soils. Nitrification was slightly reduced in soils unamended with lucerne and slightly stimulated in amended soils (i.e., organic nitrogen added). These effects, however, were not significant.

Several studies were done on the effects of the formulated products, (SC, 50% WP and 80% WP), on beneficial predators and parasites in orchards in Australia, New Zealand, and England. These populations are important biological control agents, and are used in integrated pest management programs.

The two-spotted mite predator *Typhlodromus occidentalis*, the spider mite predator *Phytoseiulus persimilis*, and a whitefly parasite *Encarsia formosa* suffered little damage relative to pest mite populations which were significantly reduced. The European red mite predators *Typhlodromus pyri* and *Agistemus longisetus*, also were favoured over the pest mite population, although one study showed there is some evidence that clofentezine is toxic to young *T. pyri* (i.e., nymph, larva, and egg). This acaricide shows potential for use in integrated pest management programs.

Wildlife Habitat Considerations. As with studies on aquatic invertebrates, difficulties were encountered in toxicity tests due to the low solubility of the technical material. In a study on the effect of technical clofentezine on the growth of a green alga, *Scenedesmus pannonicus*, the no-observable-effect-concentration was estimated to be 32 µg a.i./L nominally, although the actual concentration at the start of the experiment was an order of magnitude less than expected (i.e., 2.3 to 3.3 µg/L). At concentrations above the water solubility of the compound, growth was affected.

A study on the toxicity of Apollo SC to the green alga *Selenastrum capricornutum* indicated that algal growth was stimulated at the higher concentrations tested (16 and 50 mg a.i./L). An EC_{50} was not calculated as no effects were observed at low concentrations. This indicator species suggests that algae should not be affected should the formulated product enter an aquatic system.

No studies are available to evaluate the effects of clofentezine or Apollo SC on aquatic vascular plants or terrestrial plants. However, phytotoxic effects were looked for during field trials on the effects of formulated clofentezine on predatory mite populations. No phytotoxicity to apple trees was observed. Also, no toxicity to bush lima bean, *Phaseolus lunatus*, was observed during tests on the toxicity of Apollo SC to two-spotted and carmine spider mites.

These data suggest little impact on wildlife habitat from the use of Apollo SC in apple orchards.

Bioaccumulation. Bioaccumulation was studied using bluegill sunfish, *Lepomis macrochirus*, in a dynamic system. Fish were exposed to approximately 0.018 mg a.i./L at 22°C for 28 days. A plateau was reached after three days, and the bioaccumulation factor was estimated to be 430. Clearance half-life was less than one day.

Bioaccumulation can be predicted from correlations using the physicochemical characteristics of the pesticide such as its n-octanol:water partition coefficient (K_{ow}) and its water solubility. Clofentezine has a log K_{ow} of 3.1 and a water solubility of approximately 35 µg/L. Based on the correlation using K_{ow} developed by Veith et al. (1979), the bioaccumulation factor for fish is predicted to be 86. Similarly, using the correlation developed by Kenaga and Goring (1978, 1980), based on water solubility, the bioaccumulation factor is predicted to be 4000. The discrepancy in predictions may be due to the reported value of K_{ow}. As reported above this value is suspect. Based on the results of the bioaccumulation study previously discussed, and the low water solubility of clofentezine, the log n-octanol:water partition coefficient would be expected to be about an order of magnitude higher than reported.

Clofentezine is rapidly metabolized by mammals and fish, with a clearance half-life of less than one day. Mammals are unlikely to bioaccumulate residues of clofentezine to levels causing effects.

References. Editor's Note: This listing of references cited was not included in the Decision Document 89-03. It is provided here for your information.)

Kenaga, E.E. and C.A.I. Goring, Prerepublication copy paper given at Amer. Soc. Test. and Materials (Oct. 17-18, 1978).

Kenaga, E.E., and C.A.I. Goring, "Relationship Between Water Solubility, Soil Sorption, Octanol-Water Partitioning, and Bioconcentration of Chemicals in Biota", In: Aquatic Toxicology ASTM STP 707, (J.C. Eaton, P.R. Parrish, and A.C. Hendricks, eds.), American Society for Testing and Materials, pp. 78-115 (1980).

Veith G.D., D.L. De Foe and BV. Bergstedt, "Measuring and Estimating the Bio-concentration Factor in Fish", J. Fish Res. Bd. Can., 36:1040-1048 (1979).

INDEX

Acephate 30
Acetylcholinesterase 38
Aerial Drift of Pesticides 1, 3
Aldicarb 13
Aldrin 35
Alpha-BHC 16, 42
American Kestrel 9
American Robin 9, 30
Atlantic Puffins 10
Atrazine 12, 21, 34, 35, 42, 43
Azinphos-Methyl 9, 29
Benthic Invertebrates 44
Benzothiazole-based Pesticides 49
Bluebirds 71
Blue Mussels 5
Bloodworms 3
Burrowing Owl 92
Caddisflies 3
Canola 93
Carbofuran 29, 34, 69
Carbaryl 48, 65
Chlorothalonil 18
Cholinesterase Inhibitor 7, 9
Clofentezine 96
2,4-D 35, 42, 48
DDE 10, 51
DDT 10, 15
Deltamethrin 39, 59
Diazinon 30, 82
1,2-Dichloropropane 46
1,3-Dichloropropene 46
Dichlorvos 17
Diclofop-Methyl 35, 66
Dieldrin 10, 35, 51
Dinoseb 11
Double-crested Cormorants 52
Fathead Minnow 67
Fenithrothion 4, 5, 6, 7, 48
Fenthion 91
Fluoranthene 15
Forster's Terns 53
Free Amino Acids 23
Freshwater Clams 5
Glyphosate 28, 34, 83
Groundwater 13, 14, 60
HCB 10, 51
HCH 10
Hemlock Looper 7
Heptachlor Epoxide 10
Herring Gulls 51, 53
Lapland Longspurs 93
Leach's Storm Petrels 10
Lindane 16, 67
Malathion 29

INDEX (Cont'd)

Mallard Ducklings 69
MCPA 42
Metolachlor 21, 43
Mirex 10
Mussels 23, 47
Nontarget Plants 87
Oxychlordane 10
Organochlorine Contaminants 10
PAH 15
PCBs 10, 15, 35, 51
PCDDs 35
Phenoxys 28
Precipitation 16
Rainbow Trout 5, 65, 66, 83
Salmon 17
Spruce Budworm 5, 6, 7
Swainsons Hawks 70
2,4,5-T 35, 48
TCDF 35
Threespine Stickeback 3, 5
Tree Swallows 9
Triallate 67
Tributyltin 47
Trifluralin 67
Toxaphene 48
Water Boatmen 3
Water Fleas 3, 5, 66, 67
White-throated Sparrows 6